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Decomposing financial (in)stability in emerging economies

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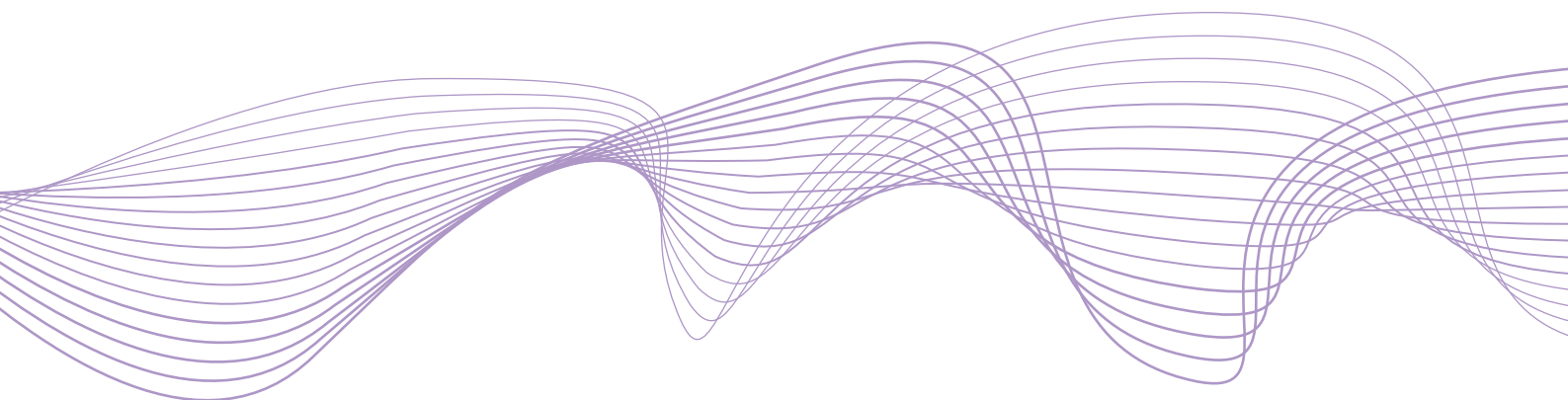
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Decomposing financial (in)stability in emerging economies

by
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European Systemic Risk Board

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Abstract

The build-up of risks in advanced economies has seen a lot of research efforts in the recent years, while similar research efforts on emerging economies have not been so strong and, when undertaken, have focused mostly on its international dimension. Simultaneously, the financial system of the emerging economies has substantially developed and deepened. In our paper, we construct an index of vulnerabilities in emerging countries, relying solely on data available at international organisations. We group indicators around four poles: valuation and risk appetite, imbalances in the non-financial sector, financial sector vulnerabilities, and global vulnerabilities. On purpose, we depart from early warning models or any other kind of complex econometric constructs. Simplicity and usability are the two key characteristics we have tried to embed into our index of vulnerabilities. We use the results to try to create a narrative of the evolution of vulnerabilities in emerging economies from 2005 to the third quarter of 2015, using innovative data visualisation tools as well as correlations and Granger causalities. We complement our analysis with a comparison between our index of vulnerabilities and the Credit-to-GDP gap.

JEL codes: E44, F65, G01, G15, G21, G23

Keywords: emerging economies, index, financial crises, risk monitoring, credit gap

I. INTRODUCTION

The build-up of risks in advanced economies has seen a lot of research efforts in the recent years, while similar research efforts on emerging economies have not been so strong and, when undertaken, have focused mostly on its international dimension: for example, examining mainly the role of foreign exchange regimes or of capital inflows. Simultaneously, the financial system of the emerging economies has substantially developed and deepened in the recent years. It may not be anymore the case that vulnerabilities are exclusively building up from external imbalances or global factors. The banking systems of emerging economies appear now better able to provide the credit needed for the economy to expand, and the shadow banking sector is growing at a comparable pace on the side. Therefore, any approach to financial stability in emerging economies shall take a holistic approach by considering all the parts in the financial system and not only those related to the external capital flows.

In our paper, we construct an index of vulnerabilities in emerging countries, relying solely on data available at international organisations. The starting assumption for our work reads that, although the financial systems of emerging economies have developed substantially, using the same approach to consider the build-up of vulnerabilities than for advanced economies may not be optimal, as fundamental differences between emerging and advanced economies still remain. In this regard, our paper follows very recent attempts to take better account of the level of financial development in the monitoring of financial stability (e.g. Marchettini and Maino 2015).

On the methodological side, we use the innovative approach of the work of Aikman et al. (2015), who have built a similar indicator for the US economy. Data availability and special considerations for the reality of emerging economies justify those cases where we depart from their methodology. We group indicators around four poles: valuation and risk appetite, imbalances in the non-financial sector, financial sector vulnerabilities, and global vulnerabilities. On purpose, we depart in our work from early warning models or any other kind of complex econometric constructs. Simplicity and usability are the two key characteristics we have tried to embed into our index of vulnerabilities.

In order to cover a significantly representative group of emerging economies, we have taken those which are qualified as that by the International Monetary Fund and which are also members of the Basel Committee on Banking Supervision: Argentina, Brazil, China, India, Indonesia, Malaysia, Mexico, Russia, Saudi Arabia, South Africa and Turkey. We use the results to try to create a narrative of the evolution of vulnerabilities in these emerging economies from 2005 to the third quarter of 2015, using innovative data visualisation tools as well as correlations and Granger causalities.

We complement our analysis with a comparison between our index of vulnerabilities and the Credit-to-GDP gap, which is used as the leading indicator for the purposes of the countercyclical capital buffer. It is possible to see how there are, in some cases, differences in the evolution of our index of vulnerabilities and of the Credit-to-GDP gap. On the one hand, such a result is expected given that the scope of the countercyclical capital buffer is limited to excessive credit growth, while our vulnerabilities index should cover a broader set of sources of financial instability. Nevertheless, this also points to the need to consider other indicators together with the Credit-to-GDP gap when setting the countercyclical capital buffer, in order to ensure that it is the right tool to address the vulnerabilities in the financial system of the emerging economy.

II. MOTIVATION & LITERATURE REVIEW

What has been done so far?

While the build-up of risks domestically in advanced economies has seen a lot of research efforts in recent years, probably due to availability of data and the efforts to build macroprudential framework and authorities, research on emerging economies has remained focused on the international side of vulnerabilities. A very important literature has developed on capital flows surge and sudden stop (e.g. Calvo and Reinhart (2000)), and on currency depreciation and appreciation. The lens of the subsequent early warning literature was in essence macroeconomic, and the indicators external ones: current account deficits, overvaluation of the currency, external borrowing, capital inflows... The focus has been also more on currency crisis than on banking crisis (Reinhart et al (2000)). When Breuer (2004) drew a typology of the different generations of models explaining crises, the models imply that crises have for most time come from abroad or from external vulnerabilities: current account deficits, too low foreign reserves, speculative attacks, forced devaluation (Krugman (1979)), or global interest rates triggering capital outflows (Dooley (2000)). Even what was called the “third generation” of models, focusing on overborrowing and overlending in emerging economies (Krugman (1999)) imply that it was the liberalization of capital controls leading to massive capital inflows which allowed the credit booms. We had to wait until the fourth generation of models, with the institutional focus of Acemoglu, Johnson and Robinson (2001, 2004) to get the lens to shift to domestic institutions, the truly exogenous variables.

But times have changed as well. Another important literature avenue has focused on financial development or financial deepening (e.g. McKinnon (1973), Shaw (1973), King and Levine (1993), Levine (2005)). Financial deepening mobilizes savings better, promotes the diffusion of information, and improves the allocation of resources and risk management via better diversification opportunities. Financial development reduces volatility by diminishing frictions and “lowers the sensitivity of financing conditions to changes in the net worth of borrowers” (IMF (2015)), thus reducing, as explained by Bernanke, Gertler and Gilchrist (1999), the amplification of cycles by the financial accelerator. It also allows more risk sharing, which allows non-financial corporations and households to be more resilient to shocks.

The financial systems of emerging markets have developed and deepened, and it may not be anymore the case that vulnerabilities are exclusively building up from external imbalances or global factors. The banking systems are now able to provide in many of these countries the credit needed for the economy to expand, and the shadow banking sector is growing at an extremely fast paced on the side. Hence, taking, for example, the specific case of China, it has very well managed to get insulated from external vulnerabilities, having implemented capital controls and being little exposed to the financial systems of other countries (IMF (2016)). Instead, the major financial stability problems that China is facing at the moment have been very much domestically sourced (The Economist (2016)): banks have lent too much, shadow banking has grown too fast, there has been an overinvestment on property markets, and a too widespread use of these very same property as collateral. A basic analysis of China today would evidence the need of looking deeper into the domestic financial systems of countries in complement to the traditional early warning indicators focused on the external imbalances.

The work on the use of the Credit-to-GDP gap, led by the BIS (Drehmann et al (2011), Drehmann

and Juselius (2012), Drehmann and Tsatsaronis (2014)), in discussing the implementation of the countercyclical capital buffer, has allowed to refocus the discussion on the domestic financial stability of emerging economies - the BIS is recommending the use of the Credit-to-GDP gap also in emerging markets as anchor for the countercyclical capital buffer. Drehmann and Tsatsaronis (2014) have justified the use of the Credit-to-GDP gap also for emerging economies despite the widespread criticism. Related to the discussion on financial development above, sceptics have argued that the Credit-to-GDP gap will be hampered by the fact that it may be problematic in a long period of financial deepening (eg Geršl and Seidler (2012), World Bank (2010)). The Credit-to-GDP gap would signal a boom in credit while a positive and beneficial process of financial development is actually underway; in other words, a “good” boom instead of a “bad” one. Moreover, the automatic application of the countercyclical capital buffer, in that case because of the signalled credit boom, would prevent countries to catch up to the financial depth of advanced economies. Drehmann himself thus concludes to the need of looking at a wide range of indicators instead of just the Credit-to-GDP gap, especially for emerging economies (Drehmann and Tsatsaronis (2014)). Recent efforts have been made to give more clarity to the relation between financial development and credit booms: Marchettini and Maino (2015) demonstrate the poor performance of the Credit-to-GDP gap in predicting crises in Sub-Saharan Africa and propose to use a gap constructed from the concept of “financial possibility frontier”, which tries to set an upper limit to financial deepening in an economy at a given point in time. They conclude that such an approach allows distinguishing “good” booms from “bad” ones and enhances the predictive power against crises.

The project of the current work

The approach taken in this paper moves voluntarily away from the crisis regression / prediction work that underlies the work of the BIS and else mentioned in the previous section. Most of the literature until now has focused indeed on regressing every variable on financial crises (e.g. Demircug-Kunt and Detragiache (1998), Rose and Spiegel (2009), Büyükkarabacak and Valev (2010), Beck et al. (2006), Boudriga and Ghardallou (2012), Bordo and Meissner (2012))¹ building then early warning framework to predict them, based on indicators with the best AUROC score and the lowest loss function for policymakers (true positive and false positive rates). Our work deliberately diverges from such exercises, for a number of reasons.

The principal problem of regressions on crisis relates to the dependent variable, namely, crisis events. They appear 1) to be too few with the countries we would like to analyse, and emerging economies, in general, to draw any robust conclusions, 2) to have a subjective definition (the quality of existing databases, even for advanced economies, requires significant rethinking), and 3) to have some confusion on the classification of crisis (systemic, systemic banking, credit, housing crises ...) which may also lead to problems for empirical work.

Another problem related to the number of crisis events is the need for indicators to have very long time series for the sample to have a bigger number of crisis dates. What is problematic then is that some indicators which are known and proven to be interesting indicators to analyse financial vulnerabilities are deliberately left out because of their short time series. The list of

¹ For a good review of the literature of banking crisis determinants, see Boudriga and Ghardallou (2012).

potential candidates thus appears severely narrowed, and the same indicators are thus used in most studies.

A final related problem is that this narrowing of the number of indicators excludes the possibility to have a granular understanding of the transmission mechanisms and underlying sources of risk leading to crises.

Departing from the traditional literature on crisis regression allows the present study to use a number of interesting indicators that may have since now been overlooked; these indicators permit a more granular understanding of the problems and a structured overview of “heat” in the financial sector.

In addition, as mentioned before, this work will go beyond the Credit-to-GDP gap and excessive credit growth indicators, allowing a better understanding of the vulnerabilities. Even though the work pioneered by the BIS on the Credit-to-GDP gap has allowed the discussion to move to the domestic financial cycle, has provided an excellent tool to monitor the build-up of excessive credit growth and has proved to be a very good predictor of crisis in any early warning system, literature has demonstrated the benefits of taking a broad range of indicators. In the literature on early warning systems, the predictive power of the Credit-to-GDP gap is increased by complementing it with indicators such as the debt-service ratio, real credit growth (Drehmann and Juselius (2012)), indicators of growth and gap of real estate sector (Drehmann and Juselius (2012), ESRB (2014)), growth of non-core liability of banks (Hahm et al (2012)), equity price growth and current account to GDP (ESRB (2014)). Behn and al (2013) conclude that there are definitive benefits at looking at a broad range of variables, including global ones, which they found to matter greatly.

The work will also shed light on existing but overlooked data. The variables used in the present paper come from a wide range of sources. As opposed to common presumptions that data for emerging economies is scarce and of poor quality, this paper highlights that the data collection work of multiple institutions can be leveraged and that sufficiently good data can be compiled to create a good overview of financial stability in emerging economies. This compiling of data is unique and allows for deeper insights into the financial system of those countries.

We build on very original efforts that have been recently developed. The paper parallels the recent work of Aikman et al (2015) who try to capture the build-up of vulnerabilities in the US financial system, building an index of heat derived from a wide range of indicators, structured in three “poles” of vulnerabilities: the non financial sector, the financial sector, and the risk appetite in financial markets. We want to continue with this “intuitive” way of looking at things, having a clear idea of how the financial system is composed and grouping indicators in this sense. The work of Aikman et al (2015) departs from the regression/prediction approach that we have argued above to be problematic, and tries instead a “narrative” approach, where, by thinking in terms of decomposition of the financial system in poles, they manage to have an idea of the channels of transmission: using Granger causality tests, they build a narrative which explains that the build up of risk starts in sector X, then transferring to sector Y, ending in sector Z.

Our objective would thus be to develop even further the framework developed by Aikman et al (2015), adapting it to emerging economies for the two following reasons: 1) it has been understudied, and 2) the domestic features of financial stability in emerging economies have

been overlooked – the literature having focused mainly on international external shocks. Finally we want to continue the promotion of a “narrative” approach to financial stability and risk monitoring.

Contribution of the monitoring framework

As emerging economies become more and more integrated in financial markets, financial spillovers from emerging economies to the EU and the US are growing rapidly (IMF (2016)) as does the size of their economy. It is not anymore the case that vulnerabilities spill in only one direction – from advanced to emerging economies. There is thus a real need for policymakers in advanced countries to have the adequate tools to monitor the financial stability risks building up in the other side of the world. A disaggregated, narrative monitoring as proposed in this paper appears a welcome move in this direction. New tools tailored to emerging economies should be launched, and future research could further develop them.

The European Systemic Risk Board (ESRB (2015)) has operationalised the possibility in the Capital Requirement Directive of increasing the resilience of the European banking sector by imposing a countercyclical capital buffer to banks that are exposed to a specific third country, where unaddressed risks are seen to build up in the latter. In this context, a sound monitoring framework is the necessary foundation to allow a better understanding of risks before taking policy action.

As for emerging economies, they would also benefit from the development of such tools, to shift the focus to the – sometimes downplayed – financial stability problems and trigger a deeper reflection on the usefulness of the macroprudential toolbox – reflection that has happened in advanced economies but might still be missing in emerging economies.

III. BUILDING THE VULNERABILITY INDEX

Indicators

Following the methodology by Aikman et al. (2015), we aim at constructing an index of vulnerabilities for each emerging economy, using a wide array of indicators. We use the same three categories that Aikman et al. (2015) used for the US (risk appetite, nonfinancial imbalances and financial-sector vulnerabilities), adding a fourth one, of particular relevance for emerging economies: external factors. This fourth category reflects the fact that developments in emerging economies are very much interlinked with the global flow of funds, in general, and with the monetary policy in the US, in particular (Taylor and Schularick (2012) and Rey (2013)).

Within each “pole”, certain components are identified. Aikman et al. (2015) identify fourteen components. In our work, mostly driven by data availability and by some structural specificities of emerging economies, we will use thirteen components, with numerous differences in the underlying indicators. Indeed, the approach we are using in this paper covers a wide range of countries and, as such, must rely on data publicly available at different international organisations. In particular, data is mostly retrieved from the IMF, the BIS and the World Bank. We have tried to make the best possible use of the information already available, relying as little

as possible on national sources of information, which would otherwise limit the comparability of the exercise². Regarding the structural specificities of emerging economies, they will be discussed in further detail as long as the indicators used are explained, but they can be summarized by saying that the role of credit in the economy of emerging countries does not fully match with its role in advanced economies as mentioned above and, as such, the risks and vulnerabilities from financial instability may also stem from different sources.

One major problem in creating indices from a wide range of indicators and for several countries is what to do with missing observations for specific indicators and specific countries. A deep look at the data availability leads us to create two samples: one that uses all data available – with the earliest date starting around 1990, and a stronger sample since 2005, where missing observations are not numerous.

Being the index purposely descriptive of current vulnerabilities and expected to be used as a monitoring tool in the coming years, a shorter sample is not necessarily a problem for our analysis. In addition, the only econometric work done in the paper – Granger causality tests – benefits from having stronger indices.

The few alternatives that have been used in the literature to deal with data gaps in the construction of indices (e.g. filling missing data with constructed data relative to the average) do not appear to fit with our purposes and have not been applied (for example, Dorrucci et al. (2009)). We have taken the view that the least number of transformations to the original database will bring stronger results. The choice of indicators in each of the component is motivated also by data availability considerations to compensate with data missing in other indicators of that component.

The following paragraphs will explain in detail the indicators allocated within each component (Table 1).

Housing. The indicator used to identify valuation pressures in the real estate sector is the real house price index. Information about home ownership ratios could also be considered, but, ultimately, the core area of interest in terms of financial stability is to identify potential vulnerabilities arising from overvaluations of real estate, regardless on whether they are acquired as an investment or for the purposes of dwelling.

Equity markets. Potential vulnerabilities stemming from equity markets are captured by looking at three indicators. The first one of them (market capitalisation as a percentage of the GDP) provides an overview of the importance of equity markets in the economy of the emerging country. Even if it is expected that the role of equity markets is not as prominent as in advanced economies, there may be cases where market capitalisation represent a significant part of the GDP of the emerging economy. At the same time, and linked with the next indicator, significant increases of the ratio may point at imbalances in prices in the equity markets. The next indicator is precisely addressing excessive growth in equity prices, which could be an indication of excessive credit being channelled to this segment of the financial markets. Finally, the price to earnings ratio aims at signalling how far fundamentals are from the current price of the shares.

² The only exception is made for the indicators on financial sector vulnerabilities for China, which are derived from CEIC Data. Otherwise, the lack of data in this component would have seriously hampered the soundness of the results for China.

Volatility. To capture vulnerabilities created by volatility in the financial markets of the emerging economy, we use the volatility of the stock prices (measured as the standard deviation of the one-year moving average) and the CDS premia. The first would be a rough measure of the risk appetite whereas the second would provide insights into the perception by financial markets of the emerging economies, especially when compared with peers.

Non-financial business. In the case of non-financial corporations, vulnerabilities in this area are tackled by considering two broad indicators: the level of credit to non-financial corporations and rate of non-performing loans (NPLs). The first indicator is used in the calculation of the Credit-to-GDP gap and as such should provide information on the potential excessive flow of credit to the real economy, potentially leading to the activation of the countercyclical capital buffer. The rate of NPLs refers to the overall economy and has been allocated in this category since NPLs are usually more prominent and cycle-dependent in the case of lending to non-financial corporations.

Consumer credit and home mortgages. In the area of credit to households, we have considered four indicators: the growth of credit to households, the aggregated debt service ratio, the loans to residential real estate as a percentage of the GDP, and the lending rates. The growth of credit to households is also used in the computation of the Credit-to-GDP gap and its relevance as predictor of excessive credit growth has been repeatedly explained in the literature. In the case of the Debt Service Ratio (DSR), it is not possible to decompose it between households and non-financial corporations and we have decided to include it in this component, since the indicator seems more relevant for loan affordability of households. Lending rates are incorporated since it can be assumed that lower lending rates may lead to an expansion of credit by increasing the volume of loans, with a potential for deterioration of the lending standards, which could give rise to further vulnerabilities in the medium-term, in case adverse macroeconomic events occur. Finally, the loans to residential real estate to GDP could have been included also in the category of housing, but the decision to keep it within the households remit is based on the fact that it is basically an indicator of the level of indebtedness of households, even if providing also indirect evidence of developments in prices and in risk appetite.

Net saving. In order to capture potential vulnerabilities from excessive or insufficient net savings, the most direct indicator to use is the gross national savings as a percentage of the GDP. The direction of the vulnerability is negative because low savings decrease the ability of the economy to withstand negative shocks. An additional informative indicator is the remuneration of deposits, where the rationale is that low values of the indicator may point towards a “search-for-yield” behaviour of savers, potentially generating vulnerabilities in some other segments of the financial system or of the real economy.

Bank leverage. Moving to vulnerabilities stemming from financial institutions, the first area of concern would be that of excessive leverage in banks. The indicators used to monitor this are tier 1 capital ratio, the non core liability ratio and the total assets to capital ratio. In the three cases, they are aimed at measuring any excessive growth in risk-taking of banks, by either considering the liabilities or the capital position. Excessive risk-taking by banks in the emerging economies is a phenomenon which may materialise over a long-term horizon.

Non-bank leverage. To measure leverage in financial institutions other than banks, there is few data which can be used to build meaningful indicators. Data availability has been here a strong

constraining force in defining the indicators. The lower degree of development of the sector of other financial corporations may explain this fact, but that should not lead to the conclusion that this sector cannot be a source of vulnerabilities. The indicators finally used in this area are the local loans of banks to the non-bank sector in foreign currency, which refers to two potentially risk practices: interlinkages between banks and non-banks and lending in foreign currency; and the ratio of non-bank credit to GDP. Both indicators are derived from data available at the BIS.

Maturity transformation. Here we use two indicators computed by the IMF in its Financial Soundness Indicators: liquid assets to short-term liabilities and total deposits to total loans. The latter draws a relation between loans and deposits in the banking system, which are at the core of the maturity transformation function of banks, whereas the former puts into relation the short-term assets with the short-term liabilities, trying to identify situations where long-term assets are funded, at least partially, by short-term liabilities.

Short term funding. In this case, indicators are mostly referred to the banking system and to the proportion of short-term liabilities to total assets and to total external debt. The first indicator (short-term liabilities to total assets) is derived from two indicators in the IMF Financial Soundness Indicators while the second is taken from the World Bank International Debt Statistics and it measures the size of external short-term debt in terms of GDP of the emerging economy. High values of these indicators could point at an excessive reliance on short-term funding, which could be the result of negative market sentiment towards that emerging economy.

Size and concentration. Indicators in this area refer to the total assets of other financial corporations to GDP, and to the total domestic claims to banks in GDP. Hence, in combination, both indicators capture the size of the banking system and of other financial corporations as percentage of the GDP. Domestic claims are used in the indicator in order not to consider the cross-border lending activity of banks of the emerging economy, which, if significant, may provide a somehow biased snapshot of the real size of the national banking system.

United States. The main variable within this category is the Fed funds rate, given the importance of US monetary policy in the capital flows within and from emerging economies (Rey (2013)). Additionally, volatility in US markets is also considered via the VIX, in order to capture episodes of turmoil which may spread to emerging economies.

External vulnerabilities. In this component, we consider five indicators which may point to imbalances stemming from the capital flows. The first one is indeed the average capital inflows in the last three years and the second one is the current account deficit or surplus to GDP. Both of them capture the flows in capital and in goods and services. Then, we have two indicators on the size of loans and liabilities of banks in foreign currency, which provide insights into the potential FX risk held by banks in the emerging economy and which could materialise in case there is sharp movement in the exchange rate. Finally, the last indicator is the overvaluation of the real exchange rate, which is aiming at identifying situations where the over (or under) valuation of the currency may give rise to adverse developments in the emerging economy.

Building the aggregated index of vulnerabilities

Within each of our four “poles”, we have a certain number of risk components – denoted k - for which we have selected a number of indicators – denoted l - giving quantitative information on

the level and build-up of vulnerabilities, whose value at a moment t for country i is denoted by $X(l,i,k,t)$.

We follow Aikman et al (2015) in standardizing our indicators by subtracting each indicator by its country specific mean and dividing by its country specific standard deviation. We take the opposite sign when the direction of vulnerability is reverse – when a smaller value for the indicator indicates higher risk. All directions of vulnerabilities are given in Table 1.

$$\tilde{X}_{l,k,i,t} = \frac{X_{l,k,i,t} - \bar{X}_{l,k,i,t}}{\sigma(X_{l,k,i,t})}$$

We aggregate the standardized indicators within each component to end up with an aggregated score for that component. We first compute a simple non-weighted average of all standardized indicators, which we then transform based on percentiles of pooled panel data (e.g., Crocker and Algina (1986)). Each country i is attributed in each period t a score for each component k , ranging from 0 to 1 (1 being the highest historical value in the sample), defined as their percentile rank in the historical distribution as follows:

$$Y_{i,k,t} = \frac{\sum_{j,\tau} I(\frac{1}{L} * \sum \tilde{X}_{l,k,j,\tau} \leq \frac{1}{L} * \sum \tilde{X}_{l,k,i,t})}{\sum_{j,\tau} Y_{k,j,\tau}}$$

where $Y_{i,k,t}$ denotes percentile ranks for a component k for a country i at time t , according to the percentile in the historical distribution of the indicator.

One important point to consider in the aggregation necessary to compile the index of vulnerabilities refers to the sample of emerging economies to take to normalize the indicators according to their distribution. The ideal would be to take the country-specific distribution. Yet, short-time series and data scarcity are two important shortcomings of this approach. At the other extreme, one could take the whole sample of emerging economies in the computation of the aggregated score. However, such a solution would not be optimal because, even within our sample of countries, there are structural and cyclical factors which differ amidst them and which need to be somehow incorporated into the score. A third solution, which remains in the middle ground of the two just briefly presented, would be to group countries with similar economies. We have broadly followed a geographic criterion under the assumption that emerging economies belonging to the same geographical area share a number of structural and cyclical factors, even if not being totally identical. On that basis, our sample of countries is allocated to the following groups: Asia (India, China, Indonesia and Malaysia), Latin-America (Mexico, Brazil and Argentina), Saudi Arabia, Turkey, Russia and South Africa. The latter four economies are too different to group them together, so we have decided to keep them alone, provided that in most cases time series are relatively long.

We finally average the score component within each pole to have a vulnerability score at the pole level. Aikman et al (2015) found that the unweighted average is doing as good a job in computing final aggregate indices as other methods – geometric average, root mean square and principal components. Equal weights have also been favoured for constructing various financial

stress indices (Danninger et al (2009), Lo Duca and Peltonen (2011), Hansen (2006), Sandhal et al (2011), Yiu et al (2010), Hanschel and Monnin (2005))³. We value the simplicity and clarity of the simple arithmetic average for the interpretation of our score and consequently apply this method. The resulting scores for our four poles can thus be averaged in a single metric of vulnerability⁴.

The vulnerability scores obtained for each country can be used for comparisons of the value of the score over time. However, due to the standardisation process introduced as a first step, cross-country comparisons exclusively based on the level of the index must be undertaken with caution⁵. The standardised values of each indicator depend on the time series of that indicator within a given emerging economy, which, for structural, historical or many other reasons may take different values than for another emerging economy.

IV. RESULTS & DISCUSSION

Descriptive statistics

As expected, the aggregated vulnerability index correlates positively with the Credit-to-GDP gap for all emerging economies, with different intensities in these correlations (Table 2). In this vein, Indonesia shows a correlation between the aggregated index and the Credit-to-GDP gap close to zero, while, on the other extreme, Argentina, Brazil, China, India, Russia and Turkey exhibit correlations over 0.5. Considering only a sample since 2005, correlations generally increase, in some cases to values close to one (Turkey, Brazil). These basic correlations are reassuring as the Credit-to-GDP gap has been found to work relatively well as an early warning indicator also for emerging economies (Drehmann and Tsatsaronis (2014)). The question is now whether our index has usefulness above and beyond the Credit-to-GDP gap. As discussed above, the latter is far from sufficient to understand the build-up of vulnerabilities, especially in emerging economies. The value added of our approach is indeed to identify vulnerabilities which are not detected by the Credit-to-GDP gap.

More interesting are the correlation matrixes among categories of vulnerabilities (external/global, valuation pressures and risk appetite, non-financial sector imbalances and financial sector vulnerability)⁶. Here, when considering the correlations between the three later, excluding the external/global factors, the correlations are small in all cases (Table 3), probably signalling very limited redundancies amongst the different indicators selected. Global and external factors are negatively correlated with the valuation pressures and risk appetite, although to a minor extent. Correlations are larger and positive in the case of non-financial sector imbalances and financial sector vulnerability, although, here, it may be more meaningful

³ For a good review of the different Financial Stress Indices and Financial Conditions Indices, see Kliesen et al (2012).

⁴ There may be certain concerns with our methodology in terms of standardisation and of computation of the vulnerability index (for example, in the cases of indicators with standard deviations close to zero or when using growth rates). OECD and JRC (2008) provide an exhaustive and rich overview of the different methodologies available for standardisation and construction of composite indicators.

⁵ In other words, if emerging economy A gets a score V_A higher than the score for emerging economy B (V_B), it cannot be automatically concluded that A is more vulnerable than B. Further analysis on the components of the score is required before reaching that conclusion.

⁶ Missing values for indicators and short-time series may render the correlation matrixes at the level of individual countries not meaningful. Hence they are only presented for the total of the sample.

to look at the dynamics of these interactions as well as to the potential Granger causalities amongst them.

It is indeed insightful to look at how the different poles are related amongst them by using the concept of Granger causality. Granger causality was first developed by the US econometrician C.W.J. Granger (Granger 1969): a variable X “Granger-causes” Y if Y can be better predicted using the histories of both X and Y than it can be using the history of Y alone. Considering the four poles in our analysis, the concept of Granger causality can be used to better understand the dynamics amidst the four poles. When the Granger causality between two poles is symmetrical, it can be inferred that they mutually increase the predicting power of the other pole, implying a contemporaneous relationship between them. In those cases where Granger causality works only in one direction, it can be possible to interpret that as vulnerabilities in one pole leading to vulnerabilities in the other. Table 4 shows the different poles which Granger-cause other poles for the eleven emerging economies under our scope.

Several insights may be taken from this analysis. First, it is remarkable how, in general, the pole of valuation and risk appetite plays a minor role in leading to the formation of vulnerabilities in the financial and non-financial sectors. Actually, only Argentina and Indonesia exhibit Granger-causality between the valuation and the financial pole. Turkey, Indonesia and Mexico depict Granger causality between the poles of valuation and global. In general terms, the non-financial and the global poles are those with the largest influence on the evolution of other poles.

Second, the pole of global factors increases the predicting power of the non-financial pole in six cases (Brazil, Russia, Turkey, Indonesia, Mexico and South Africa). The symmetric Granger causality occurs in five countries: Brazil, Argentina, Indonesia, Mexico and South Africa. It is interesting to note the narrow interaction between vulnerabilities in the non-financial sector with the external vulnerabilities and the difficulties in discerning whether the source of the vulnerabilities is external (coming from capital inflows and exposures abroad) or internal (imbalances in the non-financial sector). This may relate to our claim in the motivation of this paper that at the present moment it is no longer valid to solely attribute all financial crisis in emerging economies to external factors. Furthermore, contrary to what could be initially expected, a link with external vulnerabilities is not so often found for the financial sector (only Argentina, Brazil and China). This can also be linked to the fact that non-financial corporations in emerging economies often obtain funding in foreign currencies and/or through foreign subsidiaries and banks (which are covered by our forth pole).

Third, in some cases, it is possible to draw a chain of vulnerabilities based on these Granger-causalities, which would help to understand how vulnerabilities evolve over time (Figure 1). Argentina exhibits a pattern according to which vulnerabilities in valuation and risk appetite are later leading to the rise of vulnerabilities in the financial sector, which subsequently generate tensions in the non-financial sector; consistent with what Aikman et al (2015) find in their analysis of the US. In Malaysia, vulnerabilities in the financial sector lead to the formation of vulnerabilities in the non-financial sector, which later result in vulnerabilities in valuation and risk appetite. Similarly, in the case of China, vulnerabilities in the non-financial sector are leading to vulnerabilities in the financial sector, which later give rise to vulnerabilities in valuation.

Following the latest advances in the field of panel data econometrics, we have also tried to do the Granger test with panel data and country fixed effects. Panel vector autoregression (Panel VAR) has been increasingly used in applied research in recent years (e.g. Head, Lloyd-Ellis and Sun (2014), Carpenter and Demiralp (2012), Neumann et al (2010)). A test of the Panel VAR for Granger causality is then easily adaptable. We use these techniques and the recent Stata package developed by Abrigo and Love (2015) and apply it to our full sample to get informative hints from the general situation, keeping in mind the small number of countries, the short time series and the wide differences across emerging economies. With these relevant caveats in mind, it appears that overall in our panel, both valuation pressures/ risk appetite and global vulnerabilities Granger-cause vulnerabilities in the financial sector (Table 5)⁷, in line with the results of Aikman et al (2015) for the US and with the work of such like Adrian and Shin (2010), who have argued that increases in asset prices lead the financial sector to leverage their balance sheets even more. The Granger-causality found between the global and the financial poles is also expected in the case of emerging economies, given the important (although no longer dominant, as we argue in this paper) role of external factors (capital inflows) in these economies.

The above Granger analysis should be seen as preliminary attempts to describe our data and identify relevant patterns. It should be kept in mind that the short length of the time series and the potential changes in the number of indicators in a given quarter (as more indicators become available over time) prevent from drawing strong conclusions from the causality tests. They nonetheless might trigger some initial reflections using the narrative approach described above and can be run again as the database gets stabilised and the series lengthen.

Radar charts

One of the most important analytical visualisation devices are radar charts, where key variables are represented in the axis of a polygon and the values taken at different points in time in the different y-axis. The figure resulting from linking the different values would show how the vulnerabilities are at a certain point in time⁸. In this case, we give examples by displaying two dates on the radar charts: Q4 2009 and Q3 2015, which can describe well the post crisis developments and where the data availability is good on the whole. Admittedly, the radar charts do not allow seeing the evolution of vulnerability within those two dates (which should not be assumed as merely linear) but provide an intuitive and clear way to disaggregate an index. Figure 2 shows the radar charts for the eleven emerging economies under consideration.

A first look at the charts shows a number of common trends amidst the eleven emerging economies. To start with, global vulnerabilities have substantially increased between 2009 and 2015. Within this pole, there are factors pertaining to the US, where the emerging economies adopt a more passive role, combined with indicators measuring the interaction of the emerging economy with the rest of the world. In the first case (variables linked to the US), the increase observed has not been significant, although the value at Q3 2015 is closer to 1, the maximum. In the case of external indicators beyond those stemming from the US, especially for Brazil, Turkey, Indonesia and Malaysia, acute vulnerabilities seem to have emerged.

⁷ Table 5 presents only the most relevant Granger-causalities found.

⁸ There has been extensive discussion on whether the area covered by the radar charts at each point of time can be interpreted as the total amount of vulnerability or risk. We do not enter into this discussion, as in our paper we only compare the values taken by several variables in two points in time, not considering at all the size of the area covered by the chart.

Second, valuation pressures and risk appetite have diminished since 2009 (with the only significant exception of the housing prices in Mexico). Looking horizontally, across countries, vulnerabilities linked to equity markets and to volatility have been reduced in all of them, while those stemming from housing markets still show a strong national component. In terms of the emerging economies where the decrease is larger, Brazil, India, Turkey, Saudi Arabia and China need to be mentioned. The case of Brazil is of particular interest because it seems that there has been a shift in the source of vulnerabilities: the overall index remains in similar levels in both Q4 2009 and Q3 2015, but the vulnerabilities from global factors seem to be taking the role previously played by valuation pressures and risk appetite.

In what concerns the other two categories (non-financial sector imbalances and financial sector vulnerabilities), there are very interesting insights from a more detailed examination of the data.

In the domain of non-financial sector imbalances, vulnerabilities stemming from non-financial corporations (basically, credit to non-financial corporations and non-performing loans) seem to be lower today for several countries than in Q4 2009, with two material exceptions: India and Indonesia. This trend potentially hides some of the increase in corporate debt until 2013 or 2014. The decrease of this vulnerability is clear in Brazil (understandable as credit to non-financial corporations in recessionary times is evidently subdued) and partially in China. On the other hand, a decline of non-performing loans in Russia, South Africa, Turkey and Malaysia seem to have been the main factor for the decrease of the score. In the case of consumer credit and mortgage loans, there have been moderate increases amidst the emerging economies under consideration, with only Turkey showing a more intense growth. With the exception of South Africa, the variations in vulnerabilities related to net savings are not material.

Moving to vulnerabilities in the financial sector, there is a remarkable increase in bank leverage in Brazil, Russia and Turkey. In the case of Brazil, there has been an increase in non-bank leverage as well. Indeed, also Mexico and Malaysia show significant increases in both bank and non-bank leverage. Short-term funding has diminished overall, with the exception of Argentina, probably pointing at an extension of the maturity of the funding sources of banks in emerging economies, signalling a better access to global financial markets. Vulnerabilities from maturity transformation have grown quite substantially in Saudi Arabia and in Turkey. Finally, in terms of size of the financial sector in the total economy, there has been a large increase in the value taken by the index in all the emerging economies under consideration, in particular in South Africa and in Turkey. This seems to suggest some process of financial deepening of the emerging economies in the last five years, following several years of significant capital inflows⁹.

When looking at the situation of each emerging economy in the two points in time selected (Figure 3), there are six countries where vulnerabilities have risen in this period (Mexico, Turkey, Argentina, Brazil, Indonesia and South Africa) whereas vulnerabilities have somehow abated in five (China, Russia, India, Malaysia and Saudi Arabia). In all cases, though, it is possible to identify an evolution in the sources of vulnerabilities. To illustrate that, we take just two examples: Brazil and South Africa.

⁹ A narrative for this process can be drawn by saying that capital inflows enter massively into an emerging economy, fuelling an increase in credit and in GDP. These increases allow growth of the domestic financial sector and accentuates the process of financial deepening; this time with less weight from capital inflows.

In 2009, vulnerabilities in Brazil stemmed mainly from non-financial corporations, exuberant housing prices as well as volatility and equity markets. Six years later, the main vulnerabilities have shifted towards the financial sector (bank and non-bank leverage being the most important ones), coupled with the global vulnerabilities. So, while in 2009, the non-financial sector and the financial markets were the main threats to financial stability in Brazil, it is the financial sector which is acting like that in 2015.

In the case of South Africa, there are commonalities with those of Brazil. In 2009, sources of vulnerabilities seemed to concentrate on financial markets (equity indexes and volatility). But also the financial system and, in particular, banks were a source of concern. In 2015, on the contrary, non-bank leverage and the size of the financial system are posing important threats to financial stability in South Africa, together with global vulnerabilities and net savings. In this case, it is remarkable to note the shift within the financial system from banks to non-banks as potential sources of vulnerabilities.

Heat-maps

The previous analysis on radar charts is constructed in a way that can only consider a limited number of periods; otherwise, it would become extremely complex for the reader to interpret the many lines and vertices in the chart. An alternative to visualise the evolution of the indicators is to use heat-maps. Heat-maps are an increasingly popular tool of data visualisation for risk monitoring, as they have a very straightforward and intuitive understanding for the general public, as they allow the representation of the historical evolution of series. In the domain of financial stability, a good example is the heat map developed by the Office of Financial Research in the US. Heat-maps match risk values / scores along a gradient colour scheme with higher numbers being assigned a higher colour intensity (usually red for negative developments). In the case of our standardised risk score from 0 to 1, the mapping to a certain number of colours is an easy one, with 0 being assigned a dark green colour and 1 a dark red colour (acute vulnerabilities).

Figure 4 shows the heat-maps for our sample of emerging economies at the level of the components. We have selected the components for these purposes as, on the one hand, constructing the heat-maps over the four poles only would have summarized excessively the evolution of the underlying indicators, and, on the other hand, moving to the level of indicators would have made the heat-maps challenging to read and interpret.

The usefulness of heat-maps for the analysis of the evolution of vulnerabilities in a given economy can be illustrated with the example of China. Our vulnerability index for China peaks around the end of 2013, with values slightly above 0.65 and afterwards declines rapidly to end with 0.5 at Q3 2015.

An observation of the heat-maps show how there has been a sudden improvement of the housing component for China, which was a significant source of vulnerabilities in 2013 and 2014 and which has been rapidly corrected afterwards. Similarly, although not to the same extent, there has been an improvement in equity markets. Here, it is important to recall that we are assuming a direct positive relation between financial instability and equity prices (similarly to Aikman et al. (2015)). Hence, the observed improvement in equity markets may simply refer to a correction in prices of equities, in order to move them closer to their fundamental values. This reduction in equity prices has reduced the score for the corresponding component. Besides, it

can be observed how the main three sources of vulnerabilities for China in 2015 were the consumer credit and home mortgages, the leverage of non-banks and the size of the financial sector. These sources of vulnerabilities have remained elevated for China in the last years.

Policy considerations: relation with the Credit-to-GDP gap

It is possible to analyse how our index of vulnerabilities has evolved since 2000 in comparison with the Credit-to-GDP gap (Figure 5). For these purposes, though, and due to poor data availability in the earlier years, Argentina is excluded from the analysis¹⁰. The ten remaining emerging economies may be classified under four groups depending on how the Credit-to-GDP gap has evolved since the year 2000¹¹.

The first group is characterized by a persistent increase of the Credit-to-GDP gap, moving into positive values around 2007, which has not been interrupted by the global financial crisis or at any other time in the fifteen years under consideration. Indonesia, Mexico and Turkey belong to this group. The evolution of our aggregated score has been parallel to the increase of the Credit-to-GDP gap in the case of Mexico and Turkey: starting at values around 0.4, it is currently at its peak, close to 0.7. In the case of Indonesia, the opposite is observed: the value of the aggregated score is now approaching 0.4 while it was exceeding 0.7 in 2000. So, for Indonesia, there is no direct correlation between the score and the Credit-to-GDP gap¹². In this particular case, the credit-to-GDP gap could lead to a decision to set up a countercyclical capital buffer whereas a decomposition of the vulnerabilities in the economy would not point in the same direction. On the contrary, for Turkey and Mexico, an analysis of the Credit-to-GDP gap and of our index would lead to similar policy conclusions.

The second group comprises emerging economies where the Credit-to-GDP gap fell sharply from its peak in 2008 and which has not recovered since then. India and South Africa would belong to this group of emerging economies, with the nuance that the Credit-to-GDP gap of South Africa stopped its fall in 2012 whereas it was falling until 2014 in India. In both cases, our vulnerability score was also at its peak in 2008, around 0.7, but it has not decreased with the same intensity as the Credit-to-GDP gap. The score has been oscillating around 0.6 for India and between 0.5 and 0.6 for South Africa, while the Credit-to-GDP gap is in the negative realm for both countries since 2012. Here, the value of the Credit-to-GDP gap would suggest that there is no threat to financial stability from excessive credit growth and that any existing countercyclical capital buffer should have been released after 2008, whereas the analysis of the aggregated score could point to vulnerabilities, possibly not related to excessive credit growth, but which, even if not at the same levels as in 2008, would need to be addressed.

The third group considers countries where the Credit-to-GDP gap started to fall in 2008, reaching its floor in 2012, starting then a rapid increase to levels close to those taken just before 2008. Interestingly, the two oil exporters in our sample of emerging economies belong to this group: Russia and Saudi Arabia. In both cases, the “valley” in the evolution of the Credit-to-GDP

¹⁰ For illustrative purposes, the evolution of the vulnerability index for Argentina is included in Figure 5.

¹¹ According to the systemic banking crisis database from Laeven and Valencia (2013), only Argentina (2001), Russia (2008) and Turkey (2008) have experienced a systemic banking crisis in the period under consideration in our analysis.

¹² Actually, in Table 2 we show a correlation between the vulnerability index and the Credit-to-GDP gap close to zero for Indonesia.

gap between 2008 and 2014 has not been paralleled by our aggregated score, which, until then, followed closely the evolution of the Credit-to-GDP gap. In terms of policy, this suggests that releasing the countercyclical capital buffer would have been the most logical reaction to the decrease of Credit-to-GDP gap between 2008 and 2011, a movement which would not have been fully in line with the dynamics of our aggregated index of vulnerabilities, which remained in similar levels as in previous years. In other words, while vulnerabilities related to excessive credit growth in the years 2008 and 2011 seemed to have abated in these two economies, vulnerabilities of different nature arose and maintained our index in constant levels. In the latest observations, values of the Credit-to-GDP gap would call for setting a positive countercyclical capital buffer rate, also in line with our vulnerability index.

Finally, the forth group includes emerging economies where there has been a persistent increase in the Credit-to-GDP gap after a fall. Brazil, China and Malaysia would be allocated to this group, with the two Asian economies reaching the lowest level of the Credit-to-GDP gap in 2008, and Brazil in 2005. In all three cases, our aggregated score has evolved closely to the Credit-to-GDP gap, even if a certain divergence is observed in the latest observations: for China and Malaysia the aggregated score has diminished in opposition to the upward trend of the Credit-to-GDP gap, and for Brazil the Credit-to-GDP gap has decreased since 2014 but the aggregated score has not. In policy terms, it would mean that a certain divergence in the use of the countercyclical capital buffer for the latest observations would occur: for Brazil, the aggregated index of vulnerabilities would not support a release of the countercyclical capital buffer and for China and Malaysia the Credit-to-GDP gap would suggest a build-up of the countercyclical capital buffer which would not be supported by the evolution of our index. Hence, one could conclude that, in the latter case, there must be other factors considered in the aggregated index, which somehow compensate the risk to financial stability created by excessive credit growth and captured by the Credit-to-GDP gap.

In absolute terms, the Credit-to-GDP gap as well as the vulnerability index take the highest values for countries allocated to the first and forth groups (China, Brazil, Turkey). On the other hand, emerging economies in the second and third group are still recovering from a recent downturn and their Credit-to-GDP gap and vulnerability index are still far from their maximum values in the historical distribution. That would indicate these emerging economies in the first and forth groups would be those where vulnerabilities are of largest significance.

V. CONCLUSIONS

The methodology we are proposing in this paper to build a vulnerability index of the financial system of emerging economies is able to provide a narrative for the different sources of risks and vulnerabilities in these economies since 2005. We have opted for a simple approach, which, even if not free of caveats, is able to offer sound results and to help economists and other interested stakeholders to understand the statics and the dynamics of financial stability in emerging economies.

In particular, the comparison of the Credit-to-GDP gap with our vulnerabilities index highlights the complementarities and the different scope of both. While the Credit-to-GDP gap focuses on identifying periods of excessive credit growth with a view to use the countercyclical capital buffer to mitigate it, our vulnerability index takes a broader perspective and does consider other

threats to financial stability than excessive credit growth. These threats may be in the realm of imbalances in the non-financial sector, vulnerabilities arising from the interaction with the rest of the world, or unsustainable developments in the financial markets and in the financial system. The countercyclical capital buffer by definition is not designed to act to correct these threats but there should be other macroprudential tools available to macroprudential authorities to use if the case may be. It has been the aim of this paper to present a methodology to identify such threats to financial stability, decomposing it to the maximum extent possible and making use of publicly available data.

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Table 1. Description of indicators and direction of vulnerabilities

| | Sectors of vulnerability | Indicators | Direction of increased vulnerability | Source | Data Transformation |
|-------------------------------------|---|--|--------------------------------------|-----------|--|
| Valuation pressures / Risk Appetite | <u>Housing</u> | Real House Price | + | BIS | Growth rate |
| | <u>Equity markets</u> | Market Capitalization of listed domestic companies to GDP | + | WB | Linear Interpolation |
| | | Real Equity Price | + | Bloomberg | Growth rate |
| | | Price to Earnings Ratio | + | Bloomberg | None |
| | <u>Volatility</u> | Volatility of Real Stock Prices | + | Bloomberg | SD of 1Y return, HP filter, lambda 1600, Absolute value of the Gap |
| | | CDS Premia | - | Bloomberg | Log |
| Non-financial Sector Imbalances | <u>Non Financial business</u> | Real Credit to NFC | + | BIS | Growth rate |
| | | NPLs (% total gross loans) | + | WB | None |
| | <u>Consumer Credit & Home Mortgages</u> | Real Credit to HH | + | BIS | Growth rate |
| | | Aggregate Debt Service Ratio | + | BIS | None |
| | | Real RRE loans | + | IMF | Growth rate |
| | | Lending Interest Rates | - | WB | Linear Interpolation |
| | <u>Net Saving</u> | Gross National Savings (% GDP) | - | IMF | Linear Interpolation |
| | | Deposit Interest Rates | - | WB | Linear Interpolation |
| Financial Sector Vulnerability | <u>Bank Leverage</u> | Tier 1 ratio | - | IMF | |
| | | Capital to Assets | - | IMF | |
| | | Non core liability ratio (Hahm 2012) | + | IMF | Growth rate |
| | <u>Non Bank Leverage</u> | Local loans of banks to the non-bank sector (foreign currency) | + | BIS | Growth rate |
| | | Non bank credit to GDP | + | BIS | None |
| | <u>Maturity Transformation</u> | Liquid assets to short-term liabilities | - | IMF | None |
| | | Deposit to Total loans | - | IMF | None |
| | <u>Short term funding</u> | Short-term liabilities to total assets | + | IMF | None |
| | | External short-term debt of banks to GDP | + | WB | None |
| | <u>Size/ Concentration</u> | Assets of OFIs to GDP | + | IMF | None |
| | | Local claims to banks to-GDP | + | BIS | None |
| External/ Global | <u>US</u> | VIX | + | Bloomberg | Absolute value of the Gap, HP filter, lambda 1600 |
| | | Fed Funds Rate Effective | - | Bloomberg | None |
| | <u>External Vulnerabilities</u> | Capital inflows | + | IIF | 3Y moving average |
| | | Current Account to GDP | - | Bloomberg | None |
| | | Forex loans to total loans | + | IMF | None |
| | | Forex liabilities to total liabilities | + | IMF | None |
| | | REER gap | + | BIS | Absolute value of the Gap, HP filter, lambda 1600 |

Table 2. Correlations between the Credit-to-GDP gap and the vulnerability index

| | Simple correlation | Simple correlation (sample starting 2005) |
|---------------------|--------------------|---|
| Argentina | 0.7439 | -0.1348 |
| Brazil | 0.6332 | 0.8409 |
| China | 0.5671 | 0.6196 |
| India | 0.5026 | -0.5133 |
| Indonesia | 0.0015 | 0.6947 |
| Malaysia | 0.1670 | 0.4499 |
| Mexico | 0.4824 | 0.6925 |
| Russia | 0.5702 | 0.5295 |
| Saudi Arabia | 0.2628 | 0.1091 |
| South Africa | 0.3943 | 0.5912 |
| Turkey | 0.5892 | 0.8021 |

Table 3. Correlations amongst poles for the whole sample of emerging economies

| | Global | Financial | Non-financial | Valuation |
|---------------|----------|-----------|---------------|-----------|
| Global | 1 | | | |
| Financial | 0.222649 | 1 | | |
| Non-financial | 0.100001 | 0.166421 | 1 | |
| Valuation | -0.28589 | -0.04617 | 0.326141 | 1 |

Table 4. Detailed results of Granger causality amongst poles

| BRAZIL | | | | | CHINA | | | | | RUSSIA | | | | | TURKEY | | | | |
|-------------|-------------|-------|----|------|-------------|-------------|-------|----|------|-------------|-------------|-------|----|------|-------------|-------------|-------|----|------|
| | | chi2 | df | p | | | chi2 | df | p | | | chi2 | df | p | | | chi2 | df | p |
| global | financial | 4.90 | 3 | 0.18 | global | financial | 2.04 | 3 | 0.56 | global | financial | 3.11 | 3 | 0.38 | global | financial | 5.72 | 3 | 0.13 |
| financial | global | 14.58 | 3 | 0.00 | financial | global | 12.55 | 3 | 0.01 | financial | global | 6.42 | 3 | 0.09 | financial | global | 3.46 | 3 | 0.33 |
| global | nonfinancia | 10.91 | 3 | 0.01 | global | nonfinancia | 5.92 | 3 | 0.12 | global | nonfinancia | 8.98 | 3 | 0.03 | global | nonfinancia | 15.86 | 3 | 0.00 |
| nonfinancia | global | 9.14 | 3 | 0.03 | nonfinancia | global | 2.47 | 3 | 0.48 | nonfinancia | global | 2.97 | 3 | 0.40 | nonfinancia | global | 5.14 | 3 | 0.16 |
| global | valuation | 2.22 | 3 | 0.53 | global | valuation | 4.04 | 3 | 0.26 | global | valuation | 3.27 | 3 | 0.35 | global | valuation | 14.74 | 3 | 0.00 |
| valuation | global | 7.63 | 3 | 0.05 | valuation | global | 0.59 | 3 | 0.90 | valuation | global | 2.14 | 3 | 0.54 | valuation | global | 13.40 | 3 | 0.00 |
| global | final | 3.36 | 3 | 0.34 | global | final | 2.53 | 3 | 0.47 | global | final | 2.11 | 3 | 0.55 | global | final | 25.86 | 3 | 0.00 |
| final | global | 16.98 | 3 | 0.00 | final | global | 5.13 | 3 | 0.16 | final | global | 2.07 | 3 | 0.56 | final | global | 21.06 | 3 | 0.00 |
| financial | nonfinancia | 8.46 | 3 | 0.04 | financial | nonfinancia | 0.54 | 3 | 0.91 | financial | nonfinancia | 15.92 | 3 | 0.00 | financial | nonfinancia | 2.50 | 3 | 0.47 |
| nonfinancia | financial | 4.77 | 3 | 0.19 | nonfinancia | financial | 12.09 | 3 | 0.01 | nonfinancia | financial | 18.18 | 3 | 0.00 | nonfinancia | financial | 8.93 | 3 | 0.03 |
| financial | valuation | 1.53 | 3 | 0.67 | financial | valuation | 9.99 | 3 | 0.02 | financial | valuation | 2.24 | 3 | 0.52 | financial | valuation | 7.23 | 3 | 0.06 |
| valuation | financial | 4.64 | 3 | 0.20 | valuation | financial | 3.41 | 3 | 0.33 | valuation | financial | 0.68 | 3 | 0.88 | valuation | financial | 2.45 | 3 | 0.48 |
| financial | final | 10.99 | 3 | 0.01 | financial | final | 1.67 | 3 | 0.64 | financial | final | 10.18 | 3 | 0.02 | financial | final | 5.07 | 3 | 0.17 |
| final | financial | 14.07 | 3 | 0.00 | final | financial | 3.29 | 3 | 0.35 | final | financial | 3.86 | 3 | 0.28 | final | financial | 6.49 | 3 | 0.09 |
| nonfinancia | valuation | 2.09 | 3 | 0.55 | nonfinancia | valuation | 0.10 | 3 | 0.99 | nonfinancia | valuation | 2.88 | 3 | 0.41 | nonfinancia | valuation | 4.31 | 3 | 0.23 |
| valuation | nonfinancia | 3.39 | 3 | 0.34 | valuation | nonfinancia | 0.50 | 3 | 0.92 | valuation | nonfinancia | 4.12 | 3 | 0.25 | valuation | nonfinancia | 5.40 | 3 | 0.14 |
| nonfinancia | final | 6.55 | 3 | 0.09 | nonfinancia | final | 5.12 | 3 | 0.16 | nonfinancia | final | 11.25 | 3 | 0.01 | nonfinancia | final | 3.54 | 3 | 0.32 |
| final | nonfinancia | 24.69 | 3 | 0.00 | final | nonfinancia | 12.62 | 3 | 0.01 | final | nonfinancia | 1.49 | 3 | 0.69 | final | nonfinancia | 9.64 | 3 | 0.02 |
| valuation | final | 3.39 | 3 | 0.34 | valuation | final | 0.78 | 3 | 0.86 | valuation | final | 4.03 | 3 | 0.26 | valuation | final | 18.77 | 3 | 0.00 |
| final | valuation | 2.05 | 3 | 0.56 | final | valuation | 12.22 | 3 | 0.01 | final | valuation | 5.43 | 3 | 0.14 | final | valuation | 10.04 | 3 | 0.02 |

| ARGENTINA | | | | | INDONESIA | | | | | INDIA | | | | | MEXICO | | | | |
|-------------|-------------|-------|----|------|-------------|-------------|-------|----|------|-------------|-------------|-------|----|------|-------------|-------------|-------|----|------|
| | | chi2 | df | p | | | chi2 | df | p | | | chi2 | df | p | | | chi2 | df | p |
| global | financial | 9.58 | 3 | 0.02 | global | financial | 4.11 | 3 | 0.25 | global | financial | 0.91 | 3 | 0.82 | global | financial | 3.14 | 3 | 0.37 |
| financial | global | 8.30 | 3 | 0.04 | financial | global | 1.48 | 3 | 0.69 | financial | global | 2.39 | 3 | 0.50 | financial | global | 2.16 | 3 | 0.54 |
| global | nonfinancia | 0.43 | 3 | 0.93 | global | nonfinancia | 17.94 | 3 | 0.00 | global | nonfinancia | 0.59 | 3 | 0.90 | global | nonfinancia | 17.49 | 3 | 0.00 |
| nonfinancia | global | 7.96 | 3 | 0.05 | nonfinancia | global | 18.87 | 3 | 0.00 | nonfinancia | global | 3.63 | 3 | 0.30 | nonfinancia | global | 11.76 | 3 | 0.01 |
| global | valuation | 0.39 | 3 | 0.94 | global | valuation | 4.83 | 3 | 0.18 | global | valuation | 9.03 | 3 | 0.03 | global | valuation | 3.02 | 3 | 0.39 |
| valuation | global | 6.29 | 3 | 0.10 | valuation | global | 16.19 | 3 | 0.00 | valuation | global | 6.66 | 3 | 0.08 | valuation | global | 10.29 | 3 | 0.02 |
| global | final | 0.86 | 3 | 0.83 | global | final | 4.29 | 3 | 0.23 | global | final | 4.75 | 3 | 0.19 | global | final | 1.96 | 3 | 0.58 |
| final | global | 7.60 | 3 | 0.05 | final | global | 16.61 | 3 | 0.00 | final | global | 7.10 | 3 | 0.07 | final | global | 0.17 | 3 | 0.98 |
| financial | nonfinancia | 9.01 | 3 | 0.03 | financial | nonfinancia | 1.30 | 3 | 0.73 | financial | nonfinancia | 0.60 | 3 | 0.90 | financial | nonfinancia | 13.20 | 3 | 0.00 |
| nonfinancia | financial | 0.35 | 3 | 0.95 | nonfinancia | financial | 7.61 | 3 | 0.05 | nonfinancia | financial | 7.41 | 3 | 0.06 | nonfinancia | financial | 11.60 | 3 | 0.01 |
| financial | valuation | 3.80 | 3 | 0.28 | financial | valuation | 2.22 | 3 | 0.53 | financial | valuation | 13.05 | 3 | 0.00 | financial | valuation | 5.75 | 3 | 0.12 |
| valuation | financial | 12.89 | 3 | 0.00 | valuation | financial | 10.75 | 3 | 0.01 | valuation | financial | 2.63 | 3 | 0.45 | valuation | financial | 1.84 | 3 | 0.61 |
| financial | final | 9.29 | 3 | 0.03 | financial | final | 1.44 | 3 | 0.70 | financial | final | 3.60 | 3 | 0.31 | financial | final | 5.82 | 3 | 0.12 |
| final | financial | 5.97 | 3 | 0.11 | final | financial | 8.37 | 3 | 0.04 | final | financial | 3.15 | 3 | 0.37 | final | financial | 11.62 | 3 | 0.01 |
| nonfinancia | valuation | 2.74 | 3 | 0.43 | nonfinancia | valuation | 4.06 | 3 | 0.26 | nonfinancia | valuation | 1.33 | 3 | 0.72 | nonfinancia | valuation | 0.05 | 3 | 1.00 |
| valuation | nonfinancia | 5.33 | 3 | 0.15 | valuation | nonfinancia | 2.38 | 3 | 0.50 | valuation | nonfinancia | 3.34 | 3 | 0.34 | valuation | nonfinancia | 0.67 | 3 | 0.88 |
| nonfinancia | final | 0.32 | 3 | 0.96 | nonfinancia | final | 2.57 | 3 | 0.46 | nonfinancia | final | 2.38 | 3 | 0.50 | nonfinancia | final | 14.70 | 3 | 0.00 |
| final | nonfinancia | 1.45 | 3 | 0.69 | final | nonfinancia | 8.98 | 3 | 0.03 | final | nonfinancia | 4.05 | 3 | 0.26 | final | nonfinancia | 32.08 | 3 | 0.00 |
| valuation | final | 5.26 | 3 | 0.15 | valuation | final | 29.40 | 3 | 0.00 | valuation | final | 4.78 | 3 | 0.19 | valuation | final | 12.63 | 3 | 0.01 |
| final | valuation | 1.50 | 3 | 0.68 | final | valuation | 4.23 | 3 | 0.24 | final | valuation | 4.65 | 3 | 0.20 | final | valuation | 6.75 | 3 | 0.08 |

| MALAYSIA | | | | | SAUDI ARABIA | | | | | SOUTH AFRICA | | | | |
|-------------|-------------|-------|----|------|--------------|-------------|-------|----|------|--------------|-------------|-------|----|------|
| | | chi2 | df | p | | | chi2 | df | p | | | chi2 | df | p |
| global | financial | 1.35 | 3 | 0.72 | global | financial | 1.09 | 3 | 0.78 | global | financial | 1.04 | 3 | 0.79 |
| financial | global | 5.50 | 3 | 0.14 | financial | global | 4.26 | 3 | 0.23 | financial | global | 3.73 | 3 | 0.29 |
| global | nonfinancia | 1.59 | 3 | 0.66 | global | nonfinancia | 4.76 | 3 | 0.19 | global | nonfinancia | 10.22 | 3 | 0.02 |
| nonfinancia | global | 7.53 | 3 | 0.06 | nonfinancia | global | 2.91 | 3 | 0.41 | nonfinancia | global | 12.96 | 3 | 0.00 |
| global | valuation | 5.50 | 3 | 0.14 | global | valuation | 7.33 | 3 | 0.06 | global | valuation | 0.62 | 3 | 0.89 |
| valuation | global | 5.57 | 3 | 0.13 | valuation | global | 5.53 | 3 | 0.14 | valuation | global | 4.11 | 3 | 0.25 |
| global | final | 4.11 | 3 | 0.25 | global | final | 6.77 | 3 | 0.08 | global | final | 2.21 | 3 | 0.53 |
| final | global | 6.15 | 3 | 0.10 | final | global | 9.22 | 3 | 0.03 | final | global | 12.51 | 3 | 0.01 |
| financial | nonfinancia | 8.28 | 3 | 0.04 | financial | nonfinancia | 3.36 | 3 | 0.34 | financial | nonfinancia | 0.77 | 3 | 0.86 |
| nonfinancia | financial | 2.36 | 3 | 0.52 | nonfinancia | financial | 3.07 | 3 | 0.38 | nonfinancia | financial | 3.39 | 3 | 0.33 |
| financial | valuation | 3.72 | 3 | 0.29 | financial | valuation | 4.15 | 3 | 0.25 | financial | valuation | 3.00 | 3 | 0.39 |
| valuation | financial | 3.82 | 3 | 0.28 | valuation | financial | 4.29 | 3 | 0.23 | valuation | financial | 5.95 | 3 | 0.11 |
| financial | final | 2.84 | 3 | 0.42 | financial | final | 7.31 | 3 | 0.06 | financial | final | 1.50 | 3 | 0.68 |
| final | financial | 3.88 | 3 | 0.27 | final | financial | 2.87 | 3 | 0.41 | final | financial | 1.54 | 3 | 0.67 |
| nonfinancia | valuation | 11.65 | 3 | 0.01 | nonfinancia | valuation | 9.61 | 3 | 0.02 | nonfinancia | valuation | 1.80 | 3 | 0.61 |
| valuation | nonfinancia | 11.00 | 3 | 0.01 | valuation | nonfinancia | 7.67 | 3 | 0.05 | valuation | nonfinancia | 3.84 | 3 | 0.28 |
| nonfinancia | final | 11.19 | 3 | 0.01 | nonfinancia | final | 10.06 | 3 | 0.02 | nonfinancia | final | 4.48 | 3 | 0.21 |
| final | nonfinancia | 0.57 | 3 | 0.90 | final | nonfinancia | 1.24 | 3 | 0.74 | final | nonfinancia | 10.85 | 3 | 0.01 |
| valuation | final | 10.78 | 3 | 0.01 | valuation | final | 4.25 | 3 | 0.24 | valuation | final | 4.28 | 3 | 0.23 |
| final | valuation | 7.12 | 3 | 0.07 | final | valuation | 3.66 | 3 | 0.30 | final | valuation | 7.05 | 3 | 0.07 |

Note: Numbers highlighted in green meaning that the null hypothesis (Variable 1 does not Granger-causes Variable 2) can be rejected at the 5% significance level. Thus, Variable 1 may Granger-cause Variable 2.

Table 5. Extracted Results of Panel Granger Causality tests

| | | chi2 | df | p |
|-------------|-------------|--------|----|-------|
| nonfinancia | global | 17.979 | 3 | 0 |
| global | nonfinancia | 4.813 | 3 | 0.186 |
| nonfinancia | valuation | 10.884 | 3 | 0.012 |
| valuation | nonfinancia | 12.28 | 3 | 0.006 |
| valuation | financial | 9.101 | 3 | 0.028 |
| financial | valuation | 2.44 | 3 | 0.486 |
| global | financial | 19.139 | 3 | 0 |
| financial | global | 4.729 | 3 | 0.193 |

Note: Numbers highlighted in green meaning that the null hypothesis (Variable 1 does not Granger-causes Variable 2) can be rejected at the 5% significance level. Thus, Variable 1 may Granger-cause Variable 2.

Figure 1. Dynamics of vulnerabilities amidst the four poles based on Granger causalities

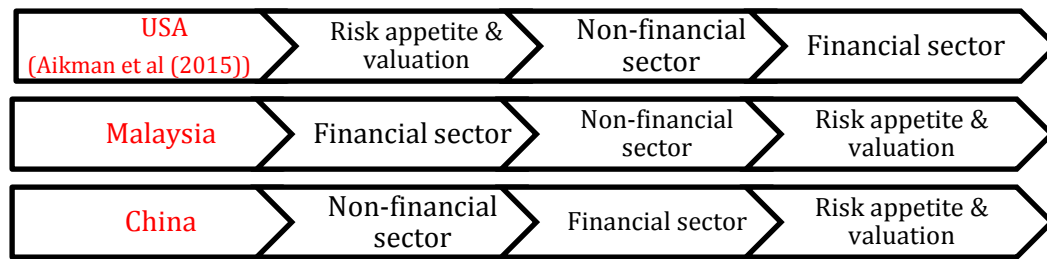
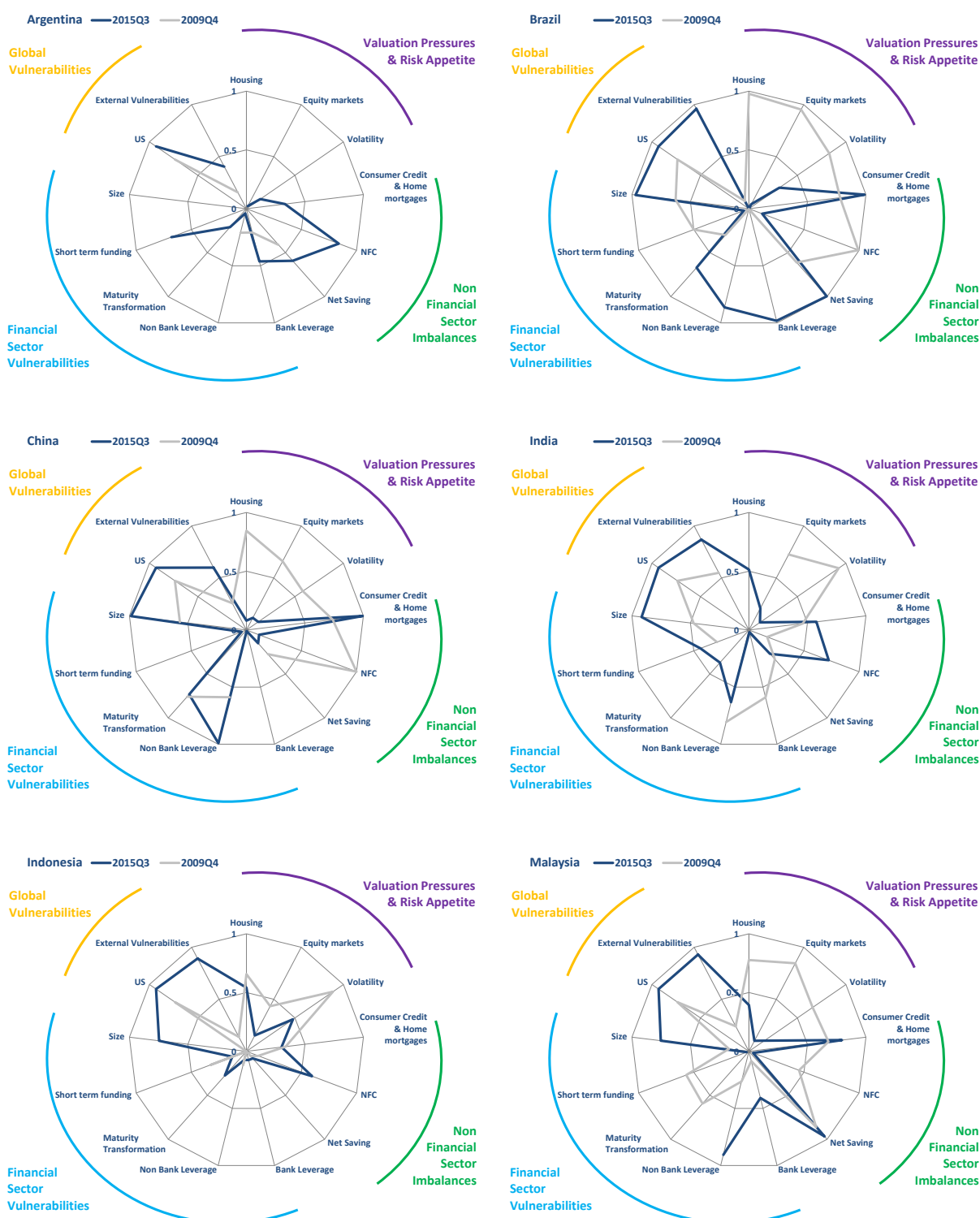


Figure 2. Radar charts of the emerging economies



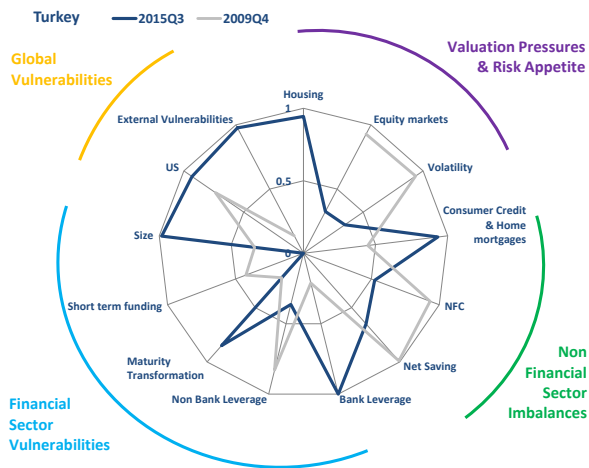
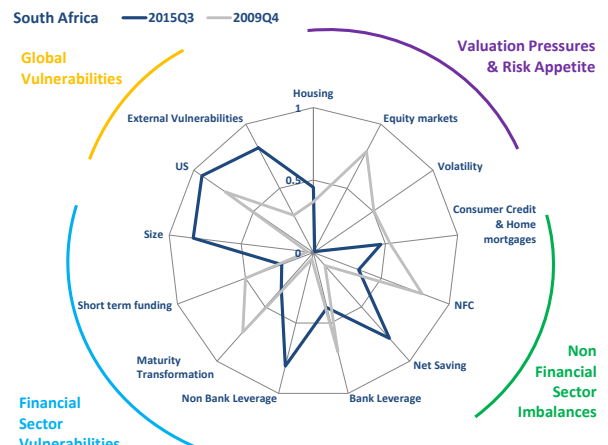
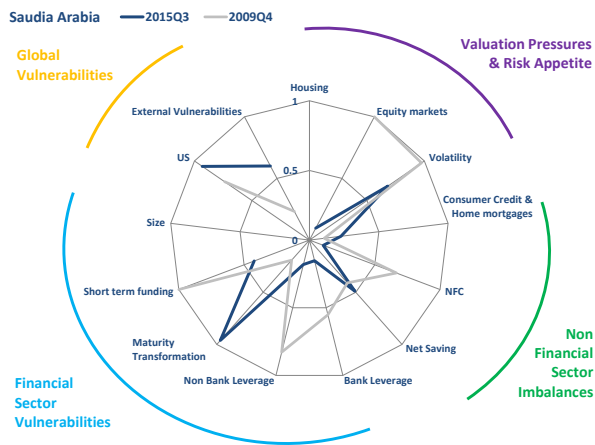
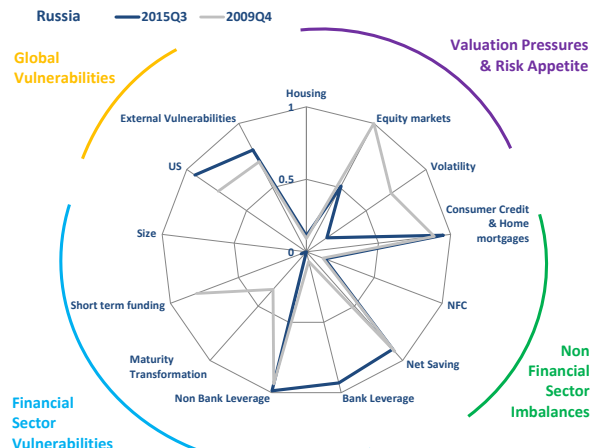
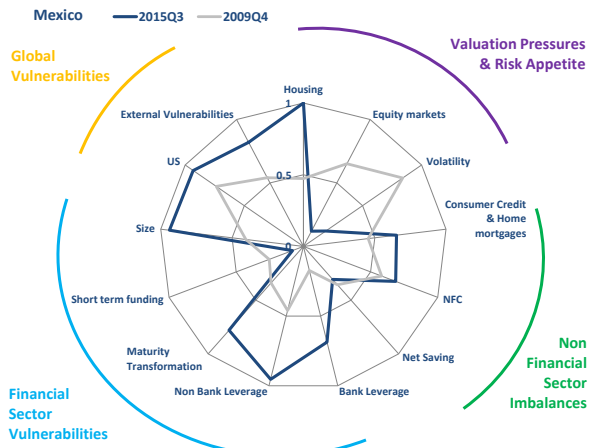


Figure 3. Evolution of the index of vulnerabilities in emerging economies between 2009 and 2015

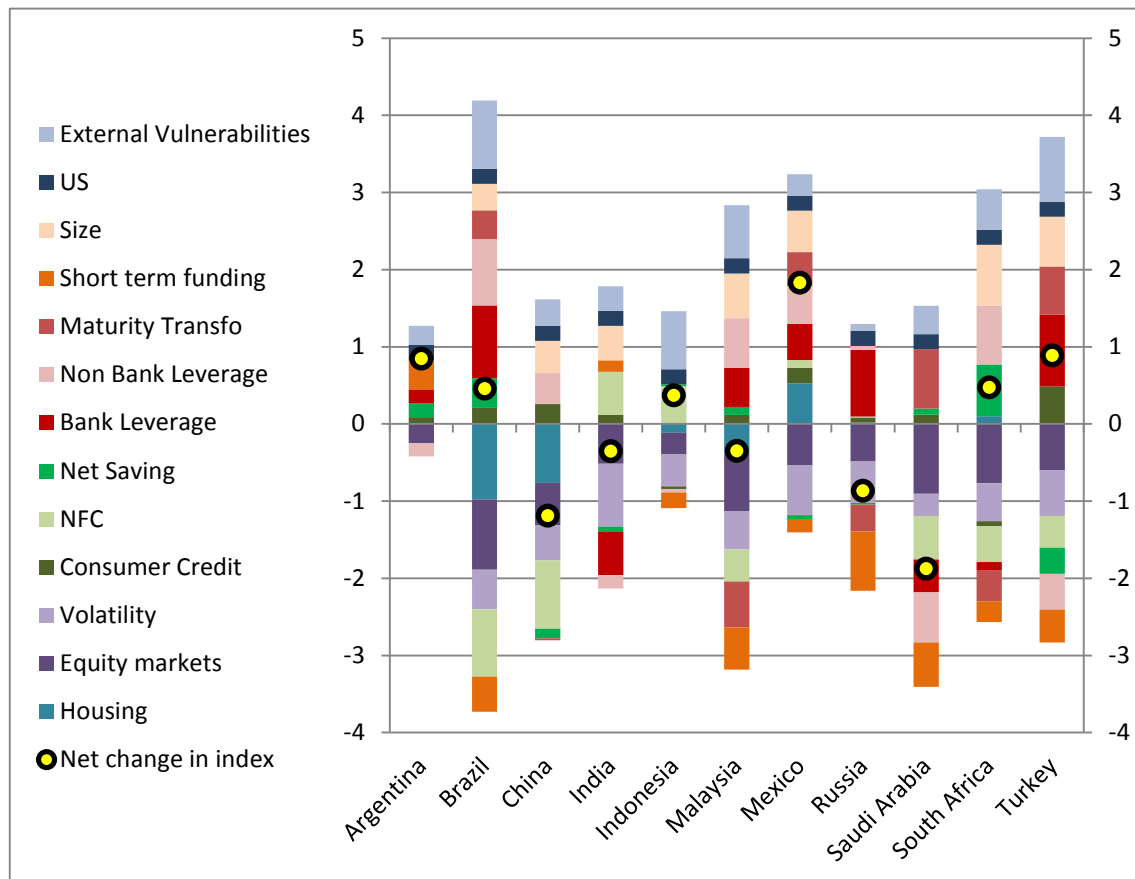
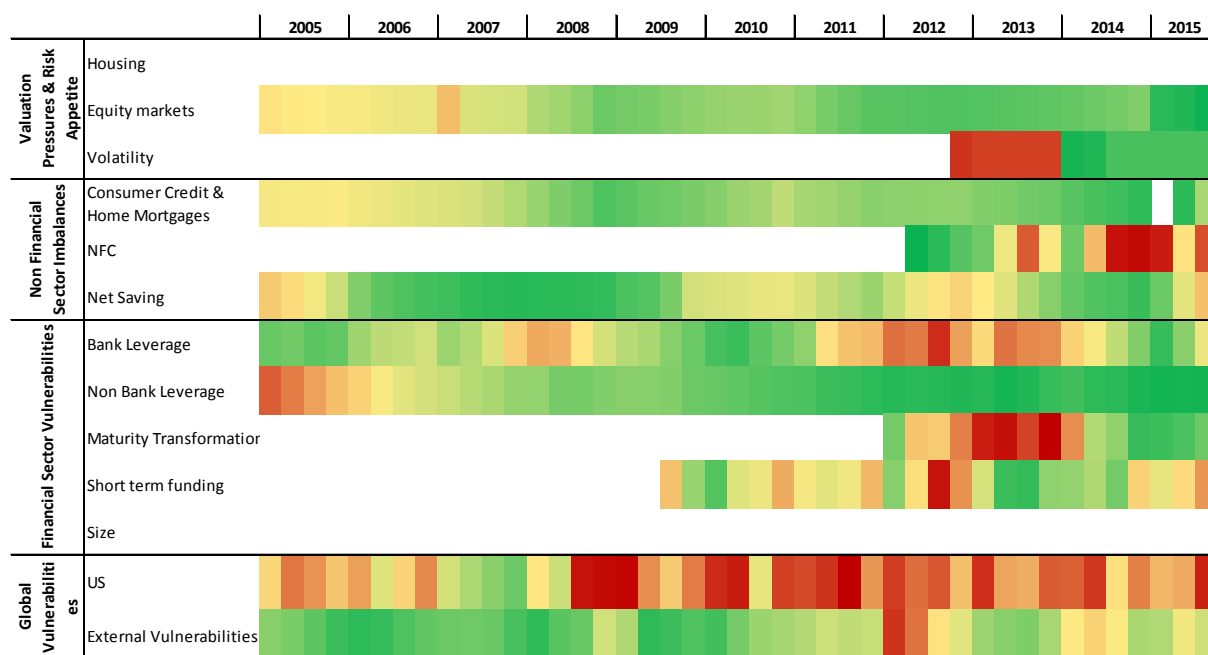
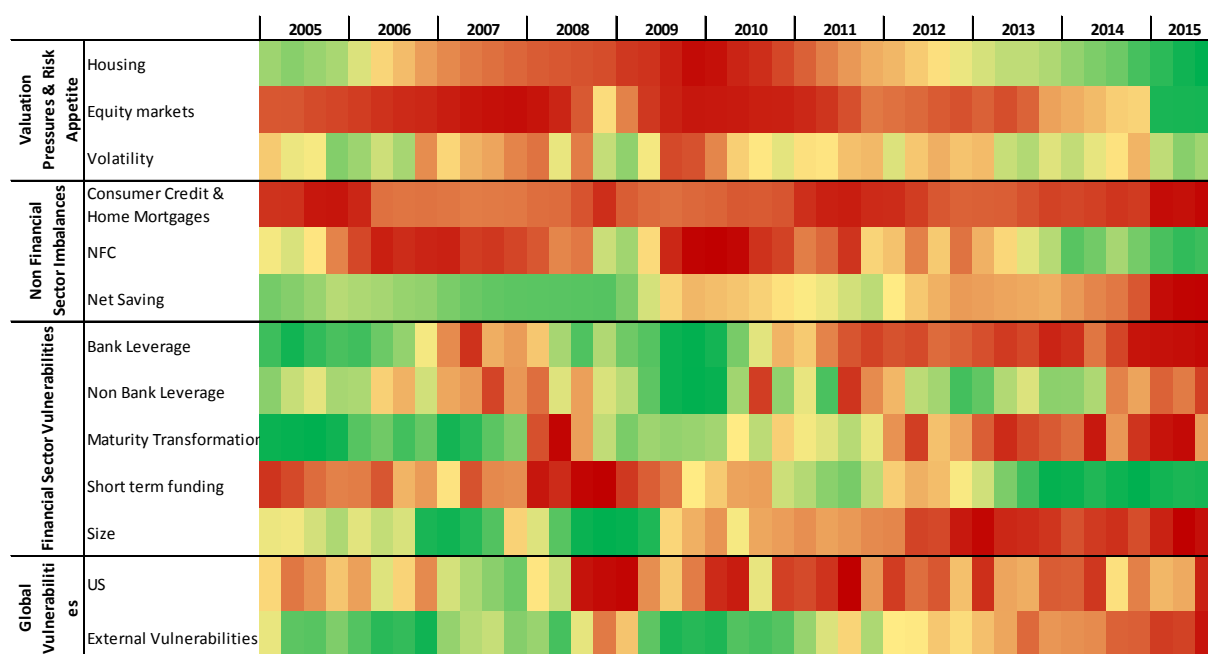


Figure 4. Heatmaps of vulnerabilities along each component

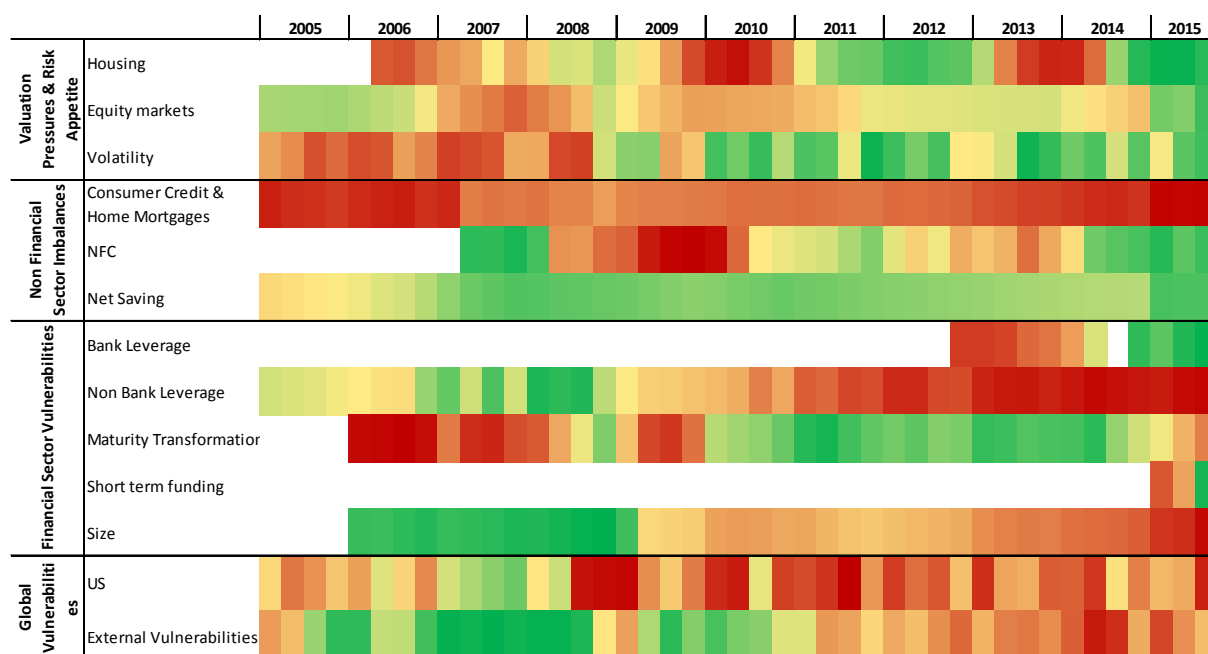
Argentina



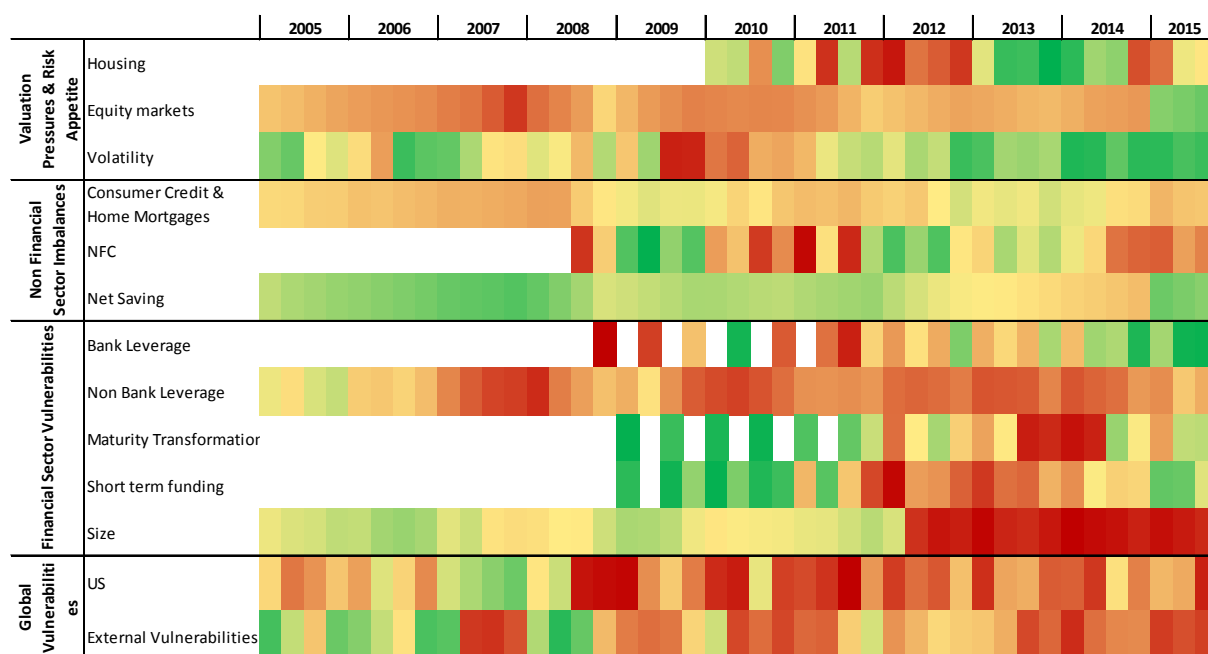
Brazil



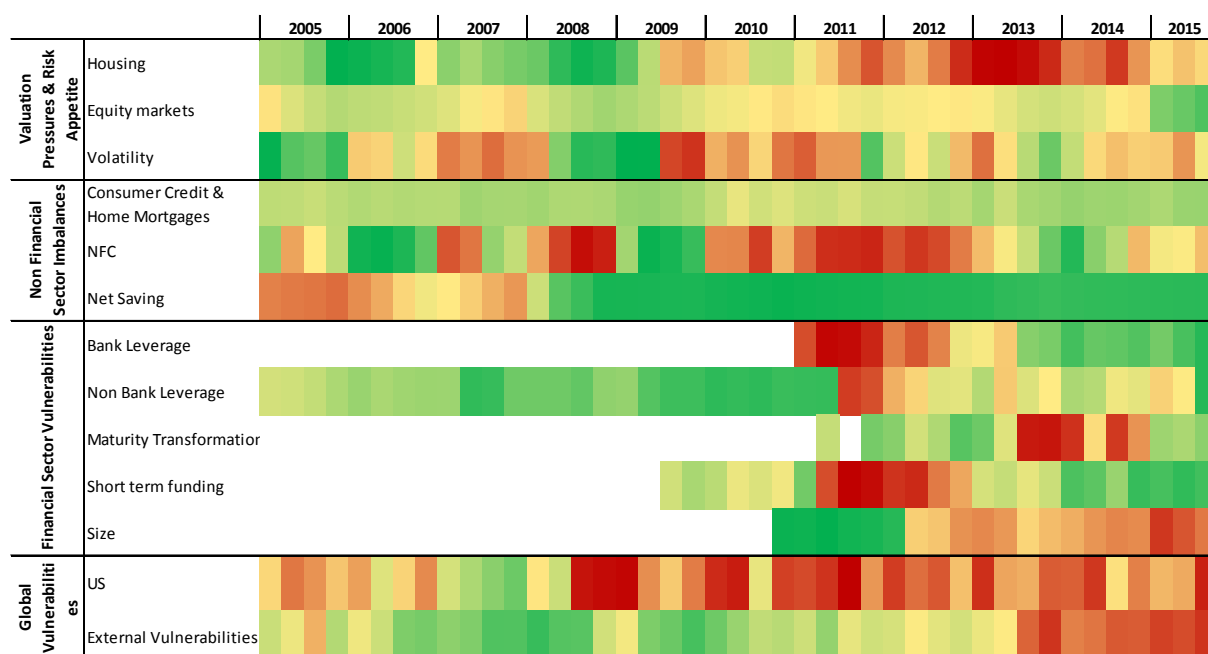
China



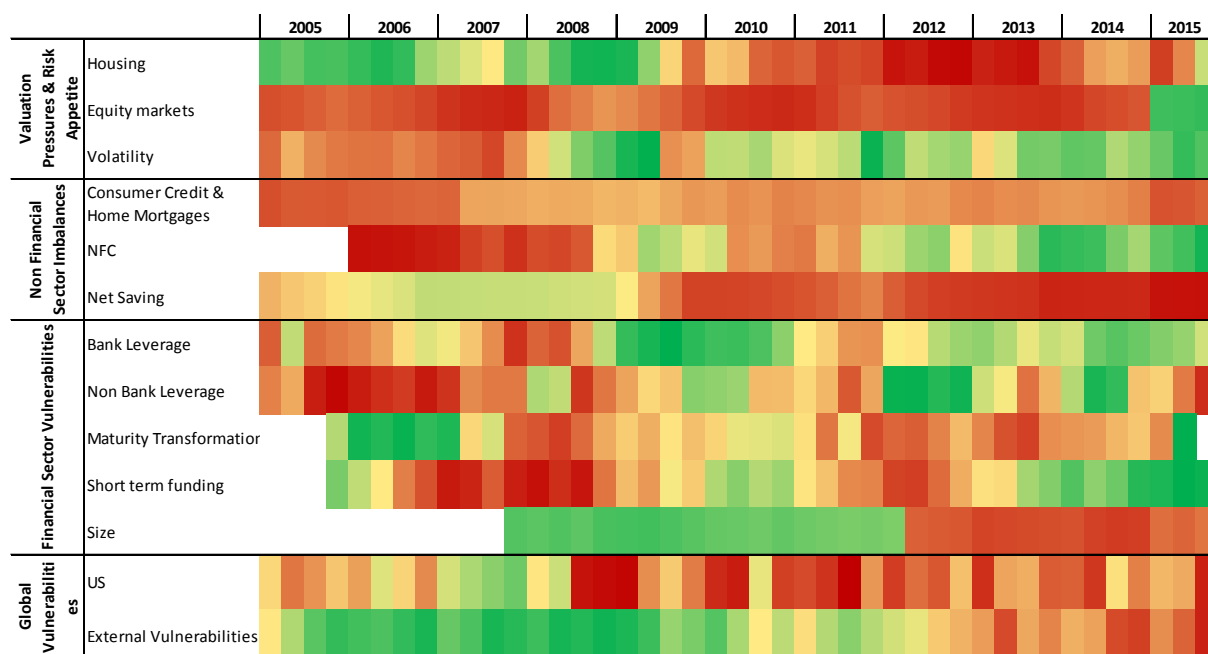
India



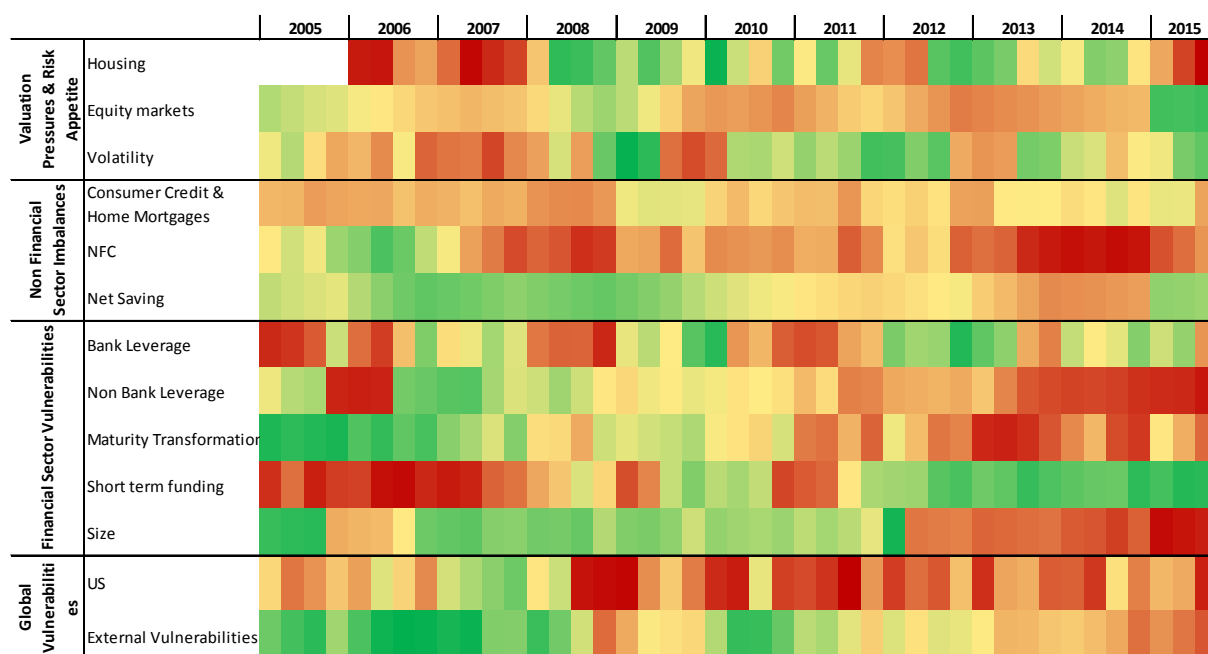
Indonesia



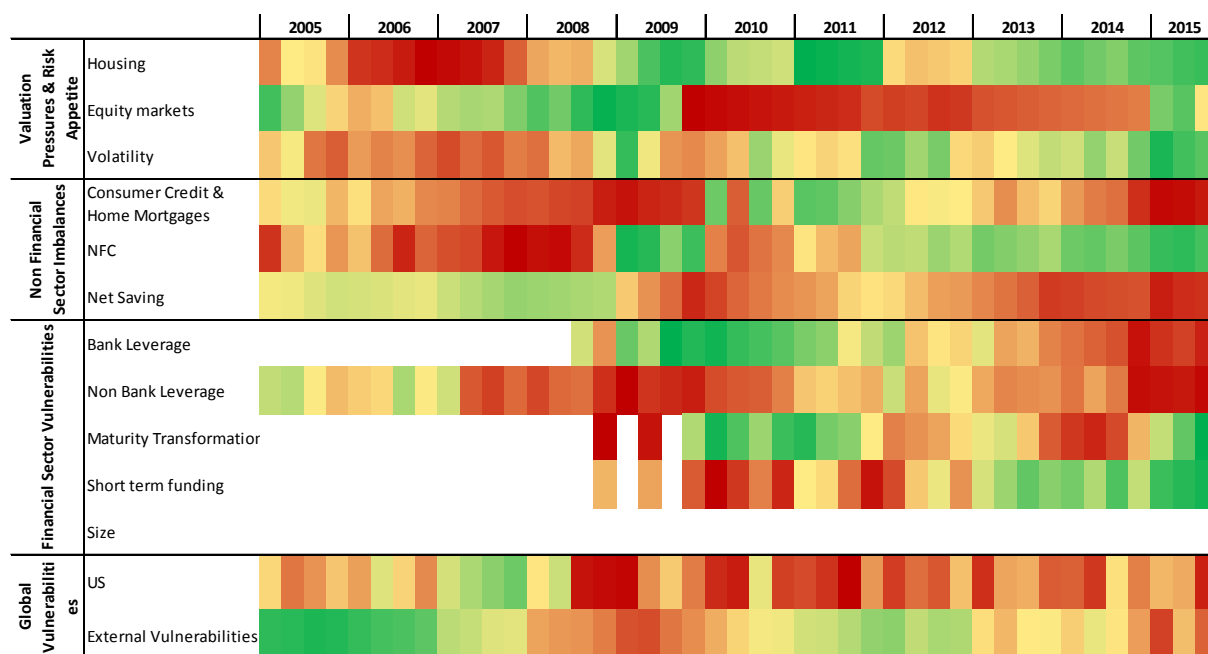
Malaysia



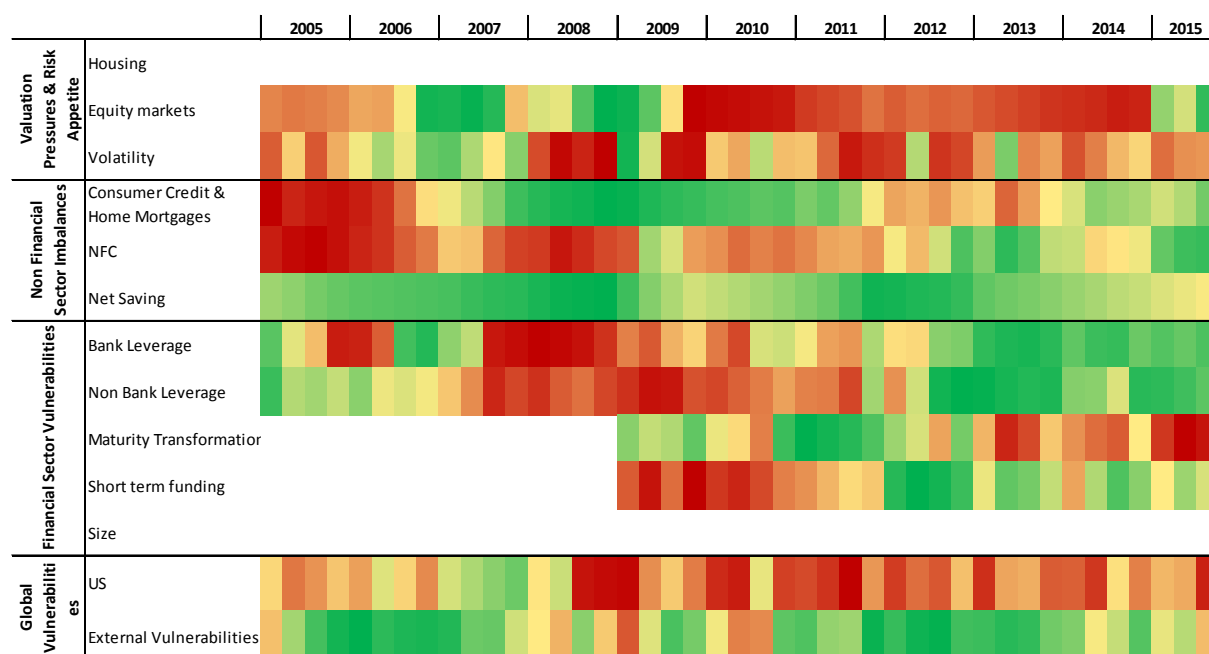
Mexico



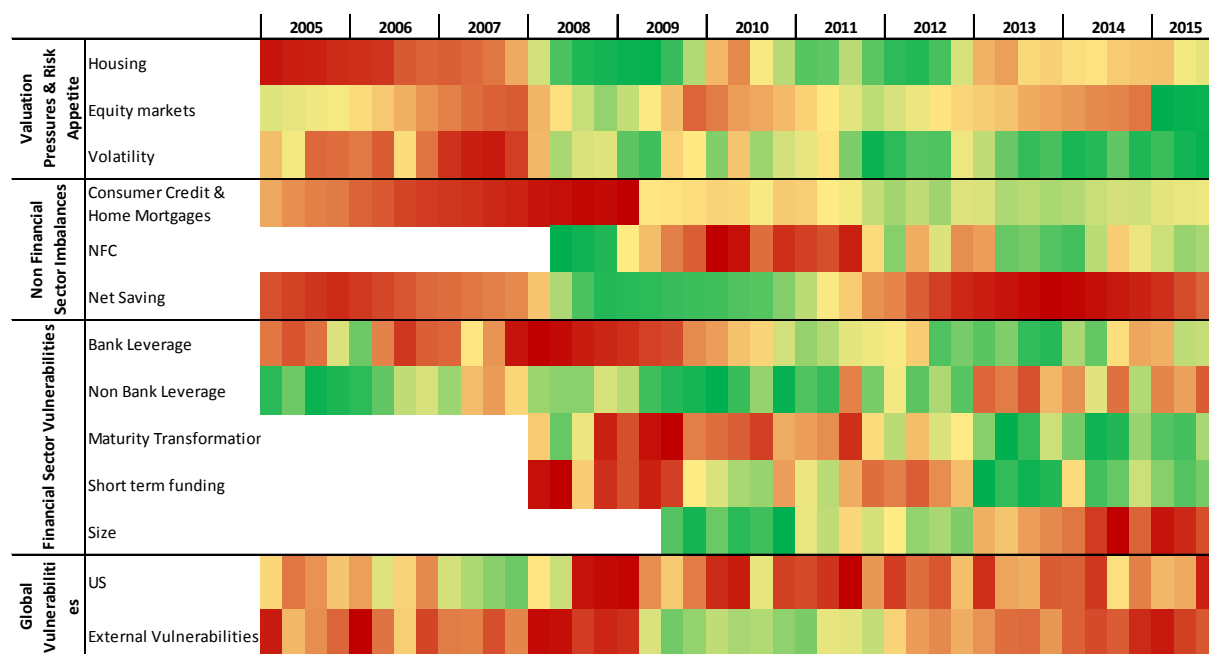
Russia



Saudi Arabia



South Africa



Turkey

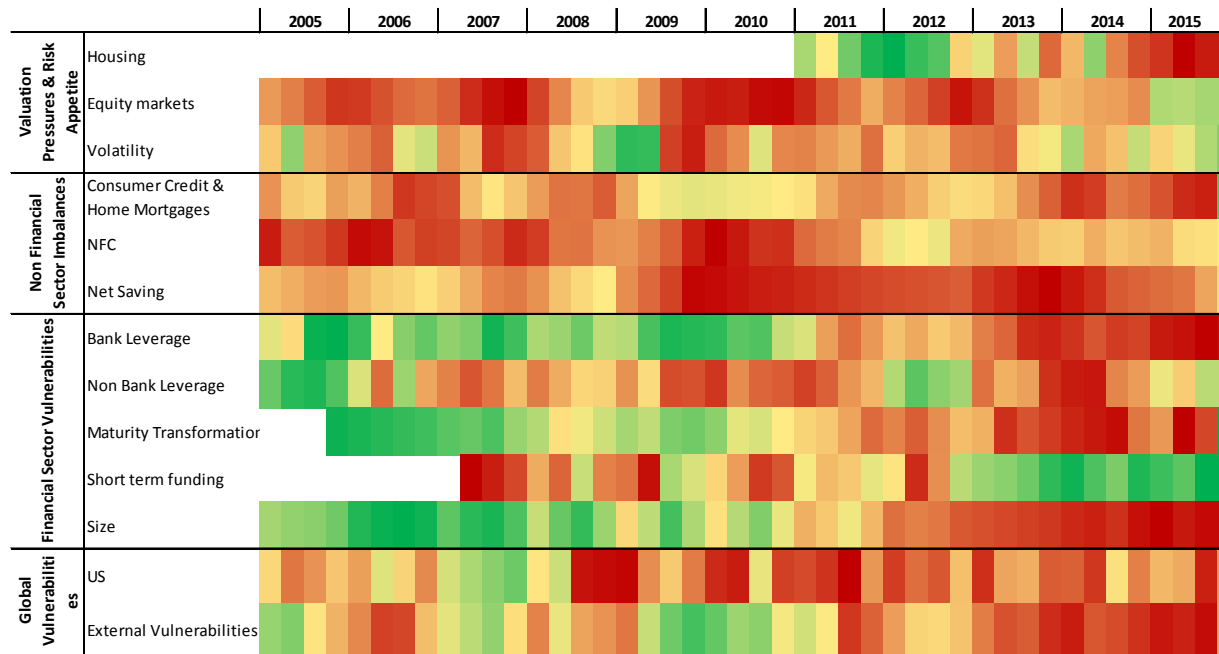
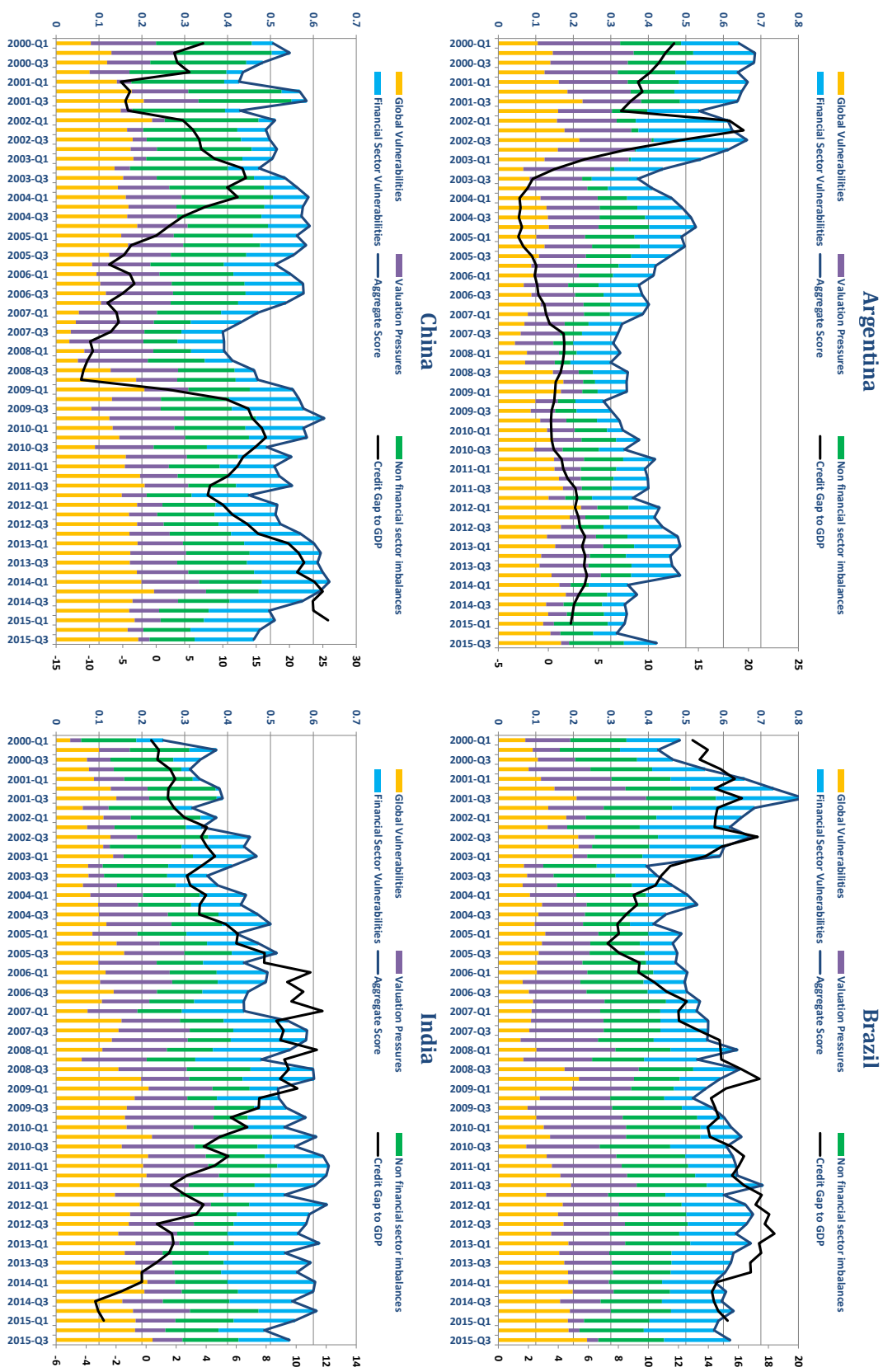
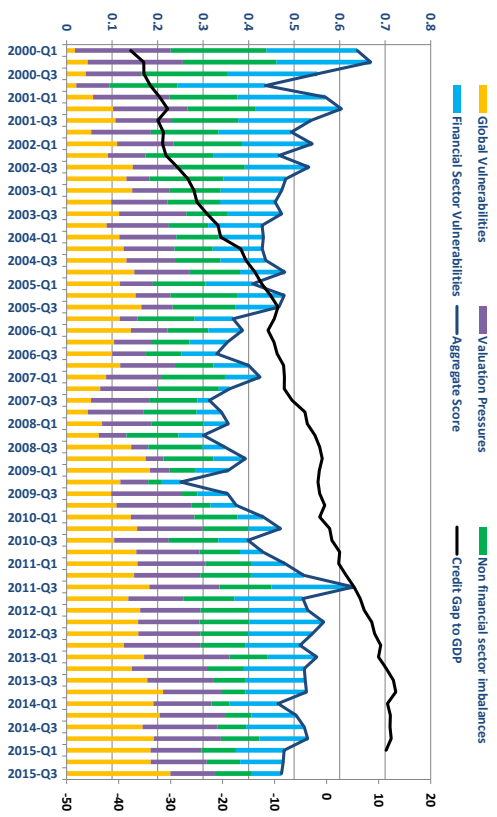


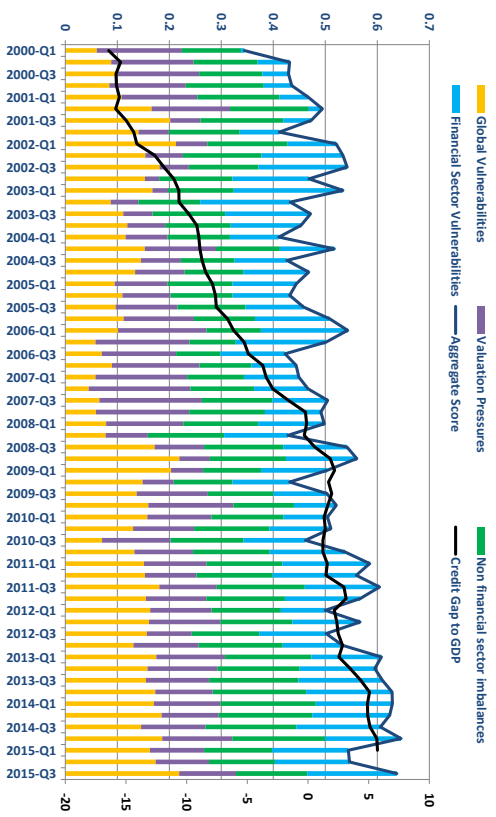
Figure 5. Vulnerabilities index and Credit-to-GDP gap



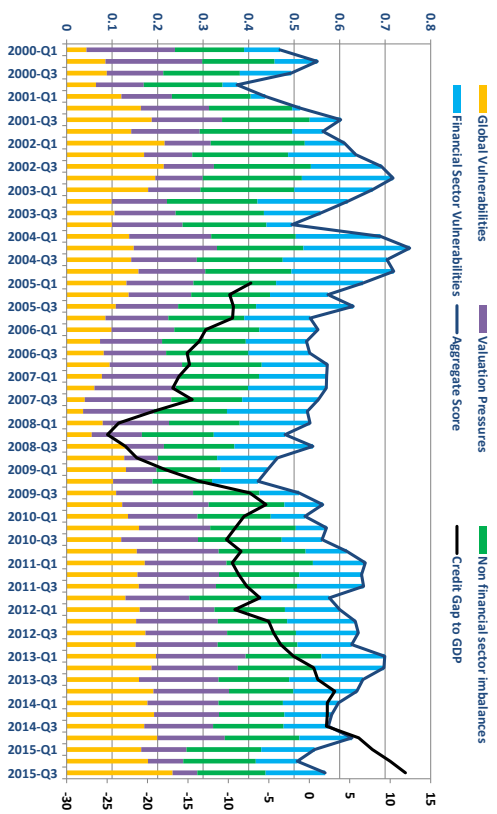
Indonesia



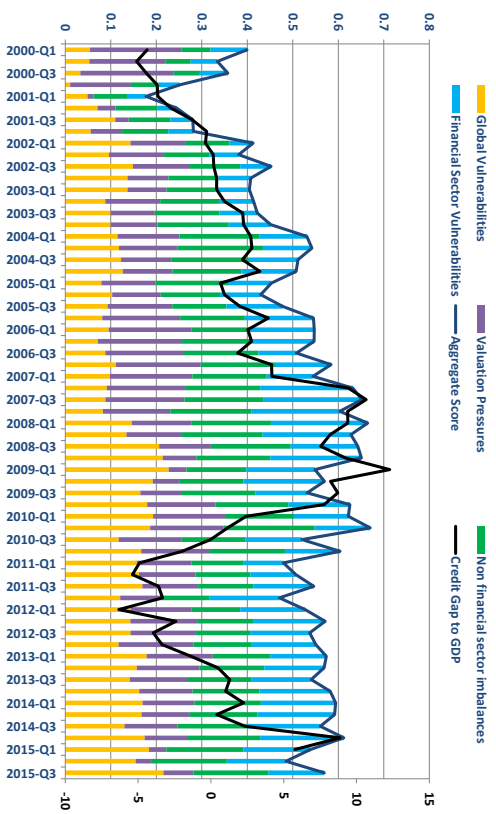
Mexico



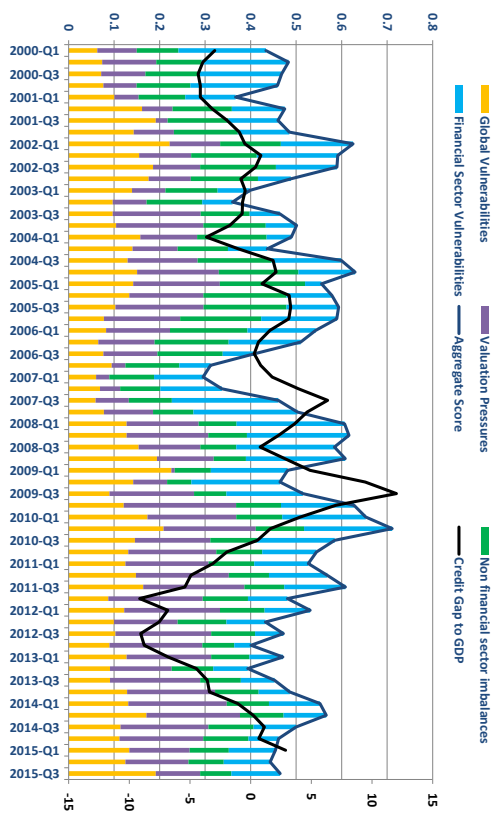
Malaysia



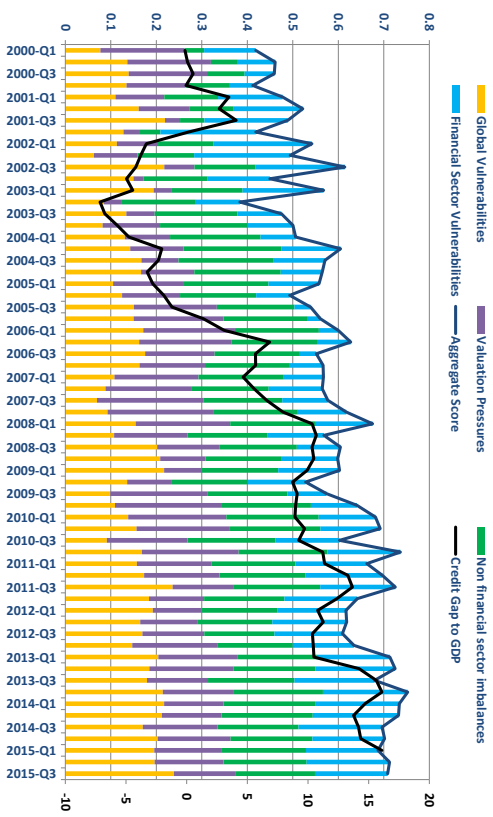
Russia



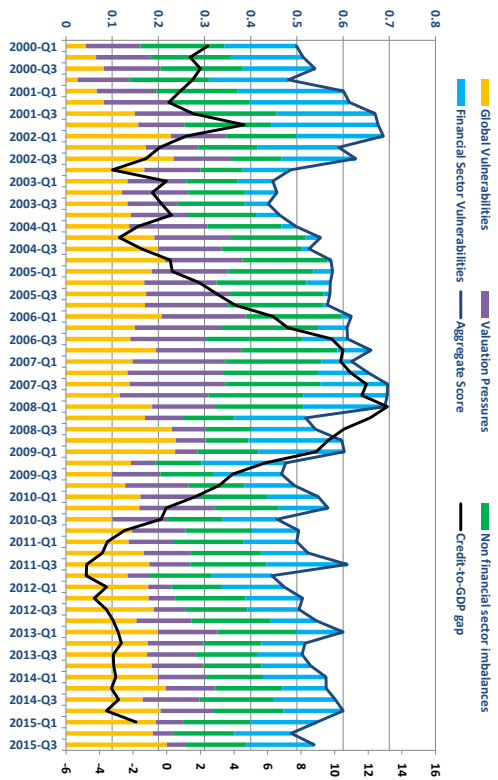
Saudi Arabia



Turkey



South Africa



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